A Practical Guide To Toxics Use Reduction

Benefitting From TUR At Your Workplace

EXECUTIVE OFFICE of ENVIRONMENTAL AFFAIRS

Commonwealth of Massachusetts
Executive Office of Environmental Affairs
Office of Technical Assistance

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Foreword

The aim of this manual is to help businesses develop and sustain Toxics Use Reduction (TUR) programs which will make sense both in terms of corporate profits and environmental protection. The manual is intended to help industry reduce or eliminate the use of toxics and/or the generation of toxic by-products at the source, before they have a chance to endanger public health and the environment.

Toxics Use Reduction often makes sense both in terms of corporate profits and environmental protection.

This manual is designed for the use of all Massachusetts institutions which use toxics -- both those which are required to do TUR planning by Massachusetts General Laws, Chapter 21 I, the Toxics Use Reduction Act of 1989 (TURA), and those small-quantity toxics users not covered by the law. The manual should prove particularly useful as a do-it-yourself guide for small and mid-sized firms which lack in-house TUR expertise yet wish to launch TUR programs.

The manual has been developed by the state Office of Technical Assistance and reviewed by businesspersons, environmental specialists and others. Our hope is that it will serve as a tool for sharing the valuable lessons derived from the hands-on experience of OTA and these business leaders.

In writing this manual, we have sought to create a document which will prove useful in the everyday work of manufacturing professionals. To this end, we have included practical step-by-step guidance to all phases of TUR, from setting up a TUR team and setting corporate TUR goals, to identifying, assessing and implementing changes which will reduce industrial toxics at the source. Where possible, we have included charts and worksheets designed to save labor and streamline the TUR planning process.

At intervals throughout the manual, we have included case studies of actual TUR activities at Massachusetts businesses. These are included for purposes of illustration only. Mention of any particular equipment or proprietary technologies does not represent an endorsement of these products by the state of Massachusetts nor an assertion that they are appropriate for every process.

How To Use This Manual

Each business will come to this manual with different needs and different levels of expertise. For instance:

* **Those who have no previous experience** with Toxics Use Reduction may wish to begin with the introductory Chapter 1 and work their way through the manual sequentially.

* **Those who already know the basics** and are ready to begin launching a TUR program may wish to dispense with the introductory Chapter 1 and start with Chapter 2.

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Executive Summary

Chapter 1: Answering Basic Questions About Toxics Use Reduction

A Toxics Use Reduction program can help your firm to improve production efficiency, cut chemical purchase and disposal costs, lower liability risks, improve worker health and safety, reduce regulatory fees and ease compliance headaches.

Toxics Use Reduction is a promising new approach to the management of toxic materials. It has been used by businesses in Massachusetts and around the country to reduce emissions of environmentally harmful toxics while often resulting in a boost in profits.

Essentially, TUR refocuses attention away from treatment of toxic wastes which have *already* been produced and toward the elimination or reduction of toxics at the point of production. Because it deals with toxic substances at the source, *before* they have a chance to become pollutants or contaminants, TUR represents the most environmentally responsible approach to the management of industrial toxics.

The aim of this manual is to help Massachusetts businesses in a variety of industries to launch successful and cost-effective TUR programs. Such a program can help your firm to improve production efficiency, cut chemical purchase and disposal costs, lower liability risks, improve worker health and safety, reduce regulatory fees and ease compliance headaches

This manual is also designed to provide general guidance to businesses subject to the planning requirements of (MGL Chap. 21 I) the state Toxics Use Reduction Act (TURA). TURA planning requirements apply to all businesses which meet *all three* of the following criteria:

* **Employ the equivalent of 10 or more full-time employees (1 employee = 2,000 work hours/year).**

* **Fall within Standard Industrial Classification (SIC) Codes 10-14 (mining); 20-39 (manufacturing); 40, 44-49 (transportation, communications, gas, electric, and sanitary services); 50, 51 (wholesale trade); and 72, 73, 75, 76 (certain services).**

* **Process or manufacture at least 25,000 pounds or otherwise use at least 10,000 pounds of substances regulated under Title III of the federal Superfund Amendment and Reauthorization Act (SARA). From 1991 to 1993, the act was expanded gradually to include all substances regulated under the federal Comprehensive Environmental Response and Compensation Liability Act (CERCLA).**

The manual has been prepared by the state Office of Technical Assistance - a *non-regulatory* state office whose purpose is to assist Massachusetts industry in its TUR efforts. OTA, which is funded by the state TURA fee, has worked with several hundred Bay State businesses and provided concrete TUR recommendations to more than 300 firms. Information about OTA's conferences, workshops, free and confidential site visits and other technical assistance services can be obtained by writing to: **Office of Technical Assistance, Executive Office of Environmental Affairs, Room 2109, 100 Cambridge Street, Boston, MA 02202** or by calling OTA at **(617) 727-3260** during business hours.

The final analytical step is the use of rudimentary materials accounting techniques to estimate the magnitude of each toxic byproduct. Once your analysis is complete, your team can conduct a formal walkthrough of your production facilities in order to check the information you have collected and begin brainstorming about process changes which might reduce reliance upon toxics.

It is important to keep in mind that the process of gathering data is intimately linked to the process of identifying TUR options. The information you gather should indicate to you where toxics are being lost, and each loss provides an opportunity for TUR. Often, TUR options will become apparent once you have identified these losses. It might be wise to have each TUR team member keep a notebook during the information-gathering stage in which to record ideas about TUR options.

The more TUR options you consider, the more likely you are to select the one that is best for your plant.

Chapter 4: Identifying TUR Options

At this point, your TUR planning efforts enter the creative phase. The object of this phase is to draw up as complete a list as possible of alternatives for reducing or eliminating your use of toxic substances and/or your generation of toxic byproducts.

Perhaps the best way to draw up such a list is to hold a group brainstorming session designed to elicit input from as many team members as possible. This will guarantee that your list of TUR options will reflect a variety of perspectives and areas of expertise.

Your brainstorming can be structured to insure that your team considers all six generic types of TUR: product reformulation, input substitution, process redesign, process modernization, improved operations and maintenance, and in-process recycling or reuse.

Of course, it is not always necessary to go through a formal options-generation process such as the brainstorming session described in this chapter. You may already be convinced that you know what needs to be done, or you may find that some common TUR technique or technology -- such as solvent substitution, metal recovery, drag-out management, chemical bath life extension, optimal process control, or improved storage and handling -- is appropriate for your business.

However, the most typical mistake at this phase is to settle for an inadequately small list of options. Keep in mind that *the more options you consider, the more likely you are to select the one that is best for your plant.*

If your in-house personnel lack sufficient familiarity with TUR techniques and technologies, you may wish to supplement your brainstorming session by contacting trade associations and industry colleagues, conducting some technical research, or soliciting help from vendors and consultants.

You may also wish to enroll one or more of your team members in classes on TUR planning. Under state law, the University of Massachusetts at Lowell has been chosen as the state's Toxics Use Reduction Institute (TURI), and has been charged with training industry employees in TUR planning. More information about TURI's classes can be obtained by writing to: **Toxics Use Reduction Institute, University of Massachusetts at Lowell, One University Avenue, Lowell, MA 01854**; or by calling **(508) 934-3275**.

Alternatively, you can call upon OTA's TUR specialists to visit your plant, study your production processes, and submit recommendations. You can reach OTA at **(617) 727-3260**.

Chapter 1: Answering Basic Questions About TUR

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This Chapter Addresses the Following Questions:

1.1	**What Is Toxics Use Reduction?**
1.2	**Why Should Your Business Pursue TUR?**
1.3	**What Does the Law Say About TUR?**
1.4	**What Is OTA and How Can It Help Your Business?**

1.0: Toxics Use Reduction -- An Overview

The Aluminum Processing Company, a Fall River-based subsidiary of Lightolier-Genlyte Group with about 250 employees, replaced a vapor degreasing process which used toxic trichloroethylene (TCE) with a non-toxic aqueous degreasing process, reducing TCE use by 80% while realizing a net profit of approximately $100,000 over the lifetime of the project.

The 110-employee Kilmartin Tool Company of southeastern Massachusetts pumped freon out of its degreasers and into sealed containers after each use, cutting its losses of ozone-depleting chlorofluorocarbons (CFCs) by 83% while saving $5,000 per year in Freon costs.

The Robbins Company, a Massachusetts-based jewelry manufacturer and plating company with about 350 workers, used readily available metal reclamation technology to cut its chemical usage by 81.8%, reduce its toxic waste generation by 89%, recycle water, and realize annual savings of $71,000 -- recouping its initial investment in less than two years.

What do these companies have in common? They have all pursued a new approach to toxic industrial byproducts which goes by the name "Toxics Use Reduction" (TUR).

TUR is a promising new approach in industry thinking about the use of toxic materials. In essence, it refocuses attention away from the treatment and disposal of toxic wastes which have already been produced, and toward the elimination or reduction of toxic substances within the production process itself.

This refocusing of attention was initiated in 1975 by the 3M Company, which estimates that its worldwide Pollution Prevention Pays (3P) program has saved it over $537 million while preventing more than 577,000 tons of pollutants and 1.7 billion gallons of wastewater. In the intervening years, 3M's ideas have been embraced by many Fortune 500 companies, including DuPont, Dow, IBM, GE, Chevron and the like. Here in Massachusetts, such businesses as Monsanto, Digital Equipment Corporation, W.R. Grace, Polaroid, Raytheon and Texas Instruments have led the way by launching their own pollution prevention

Focus: The Toxics Management Hierarchy

Massachusetts' Office of Technical Assistance recommends a hierarchy of toxics management techniques which gives highest priority to TUR. The hierarchy runs as follows:

1. Toxics Use Reduction: Wherever possible, toxic substances and/or byproducts are to be reduced or eliminated at the source, during the production process itself.

2. Recycling: Those toxic byproducts which cannot be eliminated at the source are to be recycled, either on-site or off-site.

3. Treatment: Toxic byproducts which can neither be eliminated nor recycled are to be treated to reduce their volume and/or toxicity prior to release into the environment.

4. Disposal: Only after all three of the above options have been exhausted are toxic byproducts to be landfilled, incinerated, or otherwise disposed of.

A successful TUR program requires a comprehensive examination of manufacturing processes and a detailed assessment of the costs associated with the use of various toxic materials.

TUR also improves upon other more traditional approaches to environmental control with its broad "multi-media" scope. While traditional pollution control may reduce emissions into one medium, such as the air or the water, it often does so by shifting the burden to another medium. Such burden-shifting does not count as TUR.

It is not TUR, for instance, to capture a toxic air emission with filters which themselves have to be landfilled, for this does not eliminate the costs, regulatory headaches and liability concerns associated with toxic wastes, nor does it eliminate the environmental threat posed by the toxic substance -- it merely shifts the threat from the air to the land. On the other hand, a process change which reduced or eliminated the use of this same industrial toxic would be an example of TUR.

Because TUR focuses on the use of toxic materials, a successful TUR program requires a comprehensive examination of manufacturing processes and a detailed assessment of the costs associated with the use of various toxic materials. TUR planners must gain precise knowledge of their facility's processes and operations, and they must consider, evaluate, select and implement changes aimed at reducing reliance upon toxic substances. This manual provides a guide to all phases of the TUR planning process. It introduces a variety of analytical tools for assessing manufacturing processes and weighing the costs of alternative processes.

It should be noted, however, that because TUR requires creative thinking about the specific processes and technologies appropriate to each manufacturer, the TUR planning process cannot be reduced to a handy, foolproof formula. As a result, this manual should not be seen as a guaranteed step-by-step guide to TUR success. The techniques in this manual will have to be supplemented by a thorough and creative exploration of the alternatives open to your company.

1.2: Why Should Your Business Pursue TUR?

The elimination or reduction of workplace toxics has always made good sense from the point of view of worker safety, public health and environmental protection. In Massachusetts, where hazardous waste disposal facilities currently have an inadequate capacity and access to out-of-state disposal facilities is increasingly limited, TUR is an essential element of any responsible hazardous waste policy. Many businesses have been moved by these critical concerns to initiate TUR programs.

In 1986, Massachusetts businesses produced approximately 250,000 tons of hazardous wastes, and spent an estimated $76 million to manage and dispose of those wastes. Since then, hazardous waste transportation and disposal costs have only climbed.

There are also powerful bottom-line reasons for pursuing TUR projects. In recent years, treatment and disposal costs for hazardous wastes have risen, while regulatory fees and paperwork associated with toxic materials have become increasingly steep. In 1986, Massachusetts businesses produced approximately 250,000 tons of hazardous wastes, and spent an estimated $76 million to manage and dispose of those wastes. Since then, hazardous waste transportation and disposal costs have only climbed.

Simultaneously, federal Superfund legislation has made businesses which generate hazardous wastes potentially liable for the full cost of any clean-up which may become necessary at disposal sites which they have used. Woburn, Massachusetts was recently the site of the largest Superfund settlement in New England -- a case which cost four businesses a total of $69 million. Businesses have also been hit with large fines and suits for accidental releases of toxics and for worker health problems arising from exposure to toxics. The result is that businesses which continue to produce large quantities of toxic wastes incur steep day-to-day costs and expose themselves to tremendous financial risks – risks which they often fail to appreciate fully until the day when an accident happens.

Against the backdrop of the soaring costs and liability exposure associated with the use of hazardous materials, it has begun to make increasing sense from a purely *economic* point of view to invest in alternative substances and processes which reduce reliance on industrial toxics, wherever possible. Many TUR changes require little capital and are relatively simple to carry out. These changes – which may include better storage controls, inventory management and spill prevention – often begin adding to profits almost immediately.

Quite often, even the most complex TUR changes such as process modifications or input substitutions also pay for themselves very quickly. Many companies have found that these sorts of projects can give a positive boost to bottom-line profits within one to two years.

The Benefits of TUR

Since TUR aims at the reduction or elimination of waste, it often helps manufacturers to improve their production efficiency and achieve other goals traditionally associated with quality improvement programs. For instance, TUR can help businesses to economize on materials, cut production time, improve product quality, decrease transport, treatment and disposal costs, reduce regulatory fees and compliance headaches, improve worker safety, cut worker's compensation insurance rates, and reduce their Superfund liability exposure. In addition, TUR can improve community relations and reduce the chances of public litigation.

Full appreciation of the financial benefits of TUR requires a relatively fine-toothed accounting of the costs associated with various production processes. Traditional accounting tools do not generally provide enough detail to permit calculations of the costs and benefits of TUR projects. As a result, TUR planners have stressed a form of accounting which measures *all* of the bottom-line costs and benefits associated with reduced reliance on toxics.

quantity users of toxic materials: (1) to report annually on their use of toxic substances; and (2) to undergo a planning process that involves a close examination of toxics use patterns, an evaluation of the true cost of using these toxics, and an effort to identify and evaluate TUR options. TURA sets "a statewide goal of reducing toxic waste generated by 50% by the year 1997 using toxics use reduction as the preferred means of meeting this goal." (TURA 1.1)

Who Is Subject to TURA?

In July of 1989, the Massachusetts legislature unanimously passed the Toxics Use Reduction Act (TURA), the first and one of the most ambitious state pollution prevention bills.

The planning and reporting requirements of TURA apply to firms which meet the following three criteria.

* **Employ the equivalent of 10 or more full-time employees (1 employee = 2,000 labor hours/year).**

* **Fall within Standard Industrial Classification (SIC) codes 10-14 (mining); 20-39 (manufacturing); 40, 44-49 (transportation, communications, gas, electric, and sanitary services); 50, 51 (wholesale trade); and 72, 73, 75, 76 (certain services).**

* **Process or manufacture at least 25,000 pounds or otherwise use at least 10,000 pounds of substances regulated under Title III of the federal Superfund Amendment and Reauthorization Act (SARA). From 1991 to 1993, the act was expanded gradually to include all substances regulated under the federal Comprehensive Environmental Response and Compensation Liability Act (CERCLA).**

Companies which meet *all three* of these criteria are categorized by the law as **Large Quantity Toxics Users (LQTUs)**. These firms are required by TURA to file annual reports which detail their use of listed substances and document their ongoing efforts to reduce or eliminate their dependence on these substances. By July 1, 1994, each of these businesses must also develop and certify a Toxics Use Reduction plan with specific two-year and five-year byproduct reduction goals and a detailed implementation schedule.

All Massachusetts toxics users which do not meet the above three criteria are categorized as **Small Quantity Toxics Users** (SQTUs). Certain SQTUs which fall into designated "priority user segments" may also be subject to TURA reporting and planning requirements. Under TURA, priority user segments cannot be identified until July 1, 1995.

Those toxics users who are subject to planning requirements must submit a plan summary to the state Department of Environmental Protection (DEP). The full plan must be available on facility premises for inspection by DEP officials.

Plan updates must be completed every two years after the first year in which a plan is due. These plan updates must explain any failures to meet planned goals and schedules. All plans and plan updates must be certified by the facility's senior management official and by a trained Toxics Use Reduction Planner.

Section A1.2 of Appendix 1 explains the annual TURA reporting process, while Section A1.3 of Appendix 1 describes the planning requirements. The Addendum contains the Toxics Use Reduction Act Planning Regulations (310 CMR 50.00). These planning requirements are presented in summary form in Figure 1C, which appears on the following page.

1.4: What Is OTA and How Can It Help Your Business?

To date, OTA has worked with several hundred Massachusetts businesses, and has provided on-site consultation and concrete TUR recommendations to more than 60 firms.

The Office of Technical Assistance for Toxics Use Reduction is a nonregulatory state office whose purpose is to assist industry in its Toxics Use Reduction efforts. Though OTA was established in 1989 with the passage of TURA, its precursor -- the Office of Safe Waste Management -- had by that time already gathered many years of experience helping Massachusetts businesses to reduce their use or generation of toxic substances. To date, OTA has worked with several hundred Massachusetts businesses, and has provided on-site consultation and concrete TUR recommendations to more than 300 firms. It has also held over 100 Toxics Use Reduction workshops throughout the state.

OTA is not an enforcement agency. The office's mandate is to provide technical advice and resources to companies which are subject to TURA reporting and planning requirements. It is also responsible for helping other small businesses not subject to TURA to reduce or eliminate their reliance on toxic substances. Under TURA, OTA's services are confidential and the office is required to give priority in its assistance efforts to firms referred by DEP and to companies in priority user groups.

OTA, which is funded by the TURA fee, offers the following **nonregulatory** services to Massachusetts toxics users at no charge:

* **Performs on-site Toxics Use Reduction assessments designed to help you identify TUR opportunities and learn about alternative processes and technologies appropriate to your company.**

* **Responds to telephone and written requests for general information about Toxics Use Reduction and specific information about the legal requirements of TURA.**

* **Conducts financial analyses to identify the economic benefits of TUR projects.**

* **Sponsors conferences, workshops, seminars and trade fairs to disseminate information about TUR techniques and technologies.**

* **Promotes alternative manufacturing processes that reduce toxic substance use, hazardous waste generation, toxic air emissions and wastewater discharges.**

The Office maintains an up-to-date library of resources and publications on all aspects of TUR. The library includes technical information on alternative TUR processes and technologies for a number of major industries, including metal finishing and plating, metalworking, pulp and paper, and chemical manufacturing. A partial listing of these documents is reproduced in Appendix 3 of this manual.

In addition to its direct technical assistance services, OTA may be able to help your business by putting you in touch with other companies which have faced similar toxics management problems, and which have solved them through successful TUR.

Chapter 2:
Getting Started

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2.0: Getting Started -- An Overview

Sometimes, TUR ideas can come to light immediately, with little planning. For instance, one Somerville firm recently decided, after a five-minute phone conversation with OTA, that its purchase of nitric acid etchant could be cut dramatically by installing a vacuum distillation unit which recovers acids for reuse.

Some companies using this manual may have similar experiences. They may strike upon obvious, time-tested process changes which promise immediate reductions in their toxics use and in their chemical purchase and disposal costs. A list of some of the most common and widely applicable TUR changes is included in Chapter 4 (see Figure 4H).

More typically, successful TUR requires a sustained program headed by an active TUR team. This team's task is to take the lead in analyzing production processes, identifying TUR options, submitting options to careful scrutiny, and implementing TUR process changes.

By creating such a team, your business will maximize its chances of identifying and selecting the TUR options most appropriate for it. Perhaps more importantly, the team will still be there when the project is done to help track progress, draw lessons from successes and failures, plan additional TUR projects, and build worker acceptance of TUR process changes.

This manual is written with the needs of such a TUR team in mind. This chapter focuses on forming such a team and giving it the management support it will need in order to succeed. Subsequent chapters are designed to guide the team in the investigation, identification, assessment and implementation of TUR options. However, these same chapters should provide useful guidance to those who elect to pursue TUR more informally.

2.1: Developing a TUR Policy Statement

Much like a quality improvement program, an effective Toxics Use Reduction program requires a comprehensive, company-wide shift in the way your business thinks about its production processes. Businesses which have initiated TUR programs have found that useful suggestions are likely to arise from all quarters. For instance, while engineers may be in the best position to identify and evaluate the feasibility of alternative technologies, factory

FIGURE 2B: THE TUR PLANNING TEAM:

(Note: In small firms, the same person may wear several of these hats)

MEMBER	RESPONSIBILITIES
1. MANAGEMENT	-Demonstrate corporate commitment. -Set and enforce long-term goals. -Have authority to implement changes.
2. ENGINEERING AND DESIGN	-Provide information on current processes. -Contribute ideas for changing processes. -Gauge the technical feasibility of proposals. -Identify parameters for optimal functioning.
3. ENVIRONMENTAL COMPLIANCE	-Calculate treatment and disposal costs. -Gauge environmental effects of proposals. -Ensure compliance with regulations.
4. FINANCE/PURCHASING	-Calculate costs of current operations. -Calculate costs and savings of proposals. -Track costs and benefits of actual changes. -Implement changes in inventory control.
5. SALES & MARKETING	-Provide insight into customer needs. -Educate customers about TUR changes. -Market products as environmentally responsible. -Monitor customer reactions to product changes.
6. PRODUCTION WORKERS	-Provide accurate descriptions of production practices. -Suggest ideas on new approaches. -Gauge compatibility of changes with work practices. -Supply feedback on frontline effects of changes. -Increase worker support for production line changes.

Larger Companies might consider including:

QUALITY CONTROL	-Gauge compatibility of changes with quality specs.
LEGAL	-Gauge effects of TUR on regulatory requirements. -Gauge effects of TUR on corporate liability.
SAFETY & HEALTH	-Provide data on health and safety effects of toxics. -Evaluate effects of TUR on worker health and safety.
MATERIAL CONTROL & INVENTORY	-Provide information on material storage and use. -Suggest methods for improving storage and handling.
RESEARCH & DEVELOPMENT	-Consider modifications to product design. -Consider TUR goals during new product development.

(NOTE: Adapted from the Minnesota Pollution Prevention Manual.)

Focus: The Teamwork Pay-Off:

The L. Farber Corporation, a 65-employee leather shoe components maker based in Worcester, assembled a diverse worker-management team to investigate its options for removing fats, oils and grease (FOG) from its wastewater. While the team was pondering the financial feasibility of investing in an expensive holding tank for wastewater aeration, one team member suggested that plastic-lined swimming pools could meet their needs at about one-tenth of the cost.

A technical assessment confirmed this hunch. The pools have since been installed and the system has resulted in a 95% reduction in FOG discharges at a cost thousands of dollars lower than a more conventional tank system – proving once again that many heads are better than one.

TUR goals should be consistent with the management's facility-wide TUR policy, ambitious enough to motivate significant TUR efforts, yet realistic enough to serve as an appropriate measure of success – one which will not guarantee failure from the start.

2.3: Setting TUR Goals

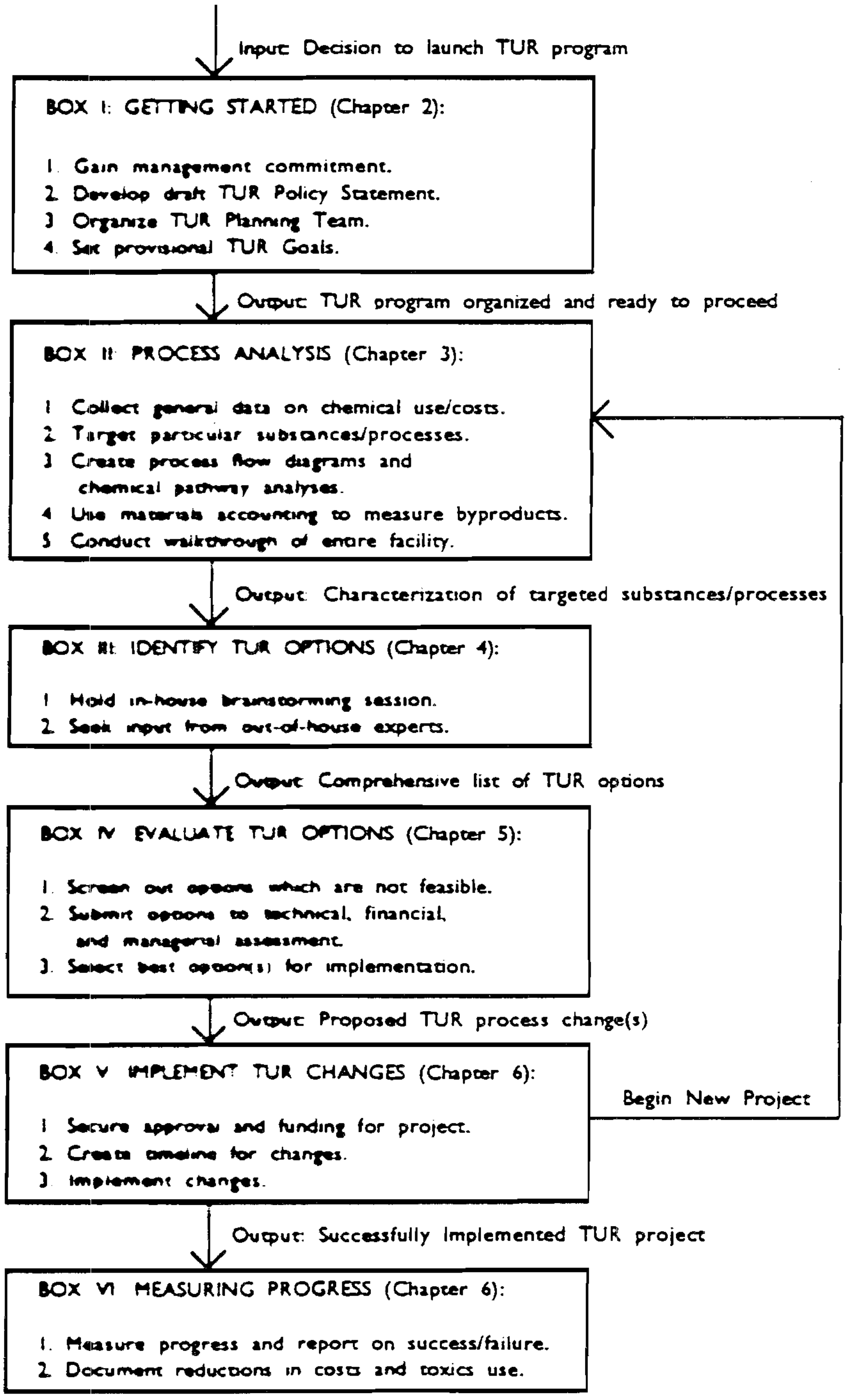
One of the first tasks facing the TUR Planning Team is the setting of TUR goals. These goals should be given a great deal of thought, as they should be consistent with the management's facility-wide TUR policy, ambitious enough to motivate significant TUR efforts, yet realistic enough to serve as an appropriate measure of success – one which will not guarantee failure from the start.

Eventually, your TUR goals should provide a specific quantified statement of the short- and long-term reductions in toxics use which you intend to achieve. However, it is not usually possible to formulate such specific goals from the very start, before your team has begun to investigate opportunities for TUR in your plant. In practice, your goals will probably evolve from qualitative directives to quantitative aims as your TUR program progresses.

For instance, you may wish to begin with the general goal of achieving a 30% reduction of toxics use and/or byproducts in two years, and a 50% reduction in five years. In many industries, such reductions are eminently achievable. Then, as you pinpoint the most promising TUR opportunities in your plant, you can make your goals more concrete. For instance, you might choose to focus your near-term efforts on reducing your use of cleaning solvents, while focusing your long-term efforts on substituting aqueous cleaners for solvent-based degreasers

Keep in mind that as you make your goals more precise, you will also want to strike upon a TUR action plan, complete with a timetable for the concrete steps you must take in order to fulfill your TUR goals. This action plan should be coordinated with your quality, efficiency, productivity, safety and energy and water conservation programs. This topic will be revisited in Chapter 6

FIGURE 2C: THE TUR FLOW CHART:



Chapter 3:
Characterizing and Analyzing Processes

Chapter 3: Characterizing and Analyzing Processes

This Chapter Addresses the Following Topics:

3.0: Analyzing Processes -- An Overview

One key to successful TUR is gaining a detailed and comprehensive picture of your toxics use patterns. The analytical tools and data which you assemble during this stage of TUR planning are absolutely critical, as they are your primary means for pinpointing wasteful practices, identifying TUR opportunities, and calculating the costs and benefits of proposed changes.

This chapter walks you through the process of analyzing your production processes -- beginning with the most general information-gathering stages, and working towards the highly detailed analysis of individual processes needed to spot TUR opportunities.

Those firms which have already chosen a particular process for focused examination may wish to turn directly to 3.3 and begin constructing process flow diagrams of those processes.

If your team feels, at any stage in the process, that a visit to the factory floor is needed in order to get a better picture of production processes, you may wish to turn ahead to Part 5, which explains how to organize a group walkthrough.

It is important to keep in mind that the process of gathering data is intimately linked to the process of identifying TUR options (described in Chapter 4). The information you gather should indicate how much your toxics cost you and where they are being used inefficiently. This alone often brings to mind alternative techniques and processes. It is a good idea to have each TUR team member keep a notebook during the information-gathering stage in which to record ideas about TUR options.

3.1: Gathering and Organizing Information

With a TUR Policy Statement and tentative TUR goals already in place, your team is now ready to sharpen its knowledge of the use of toxics on premises. The first data-gathering goal is to gain a general overview of the chemicals which enter and leave your facility. This information has uses which extend far beyond TUR planning. It should prove useful in

Just as with the first database, this basic information may be supplemented as your TUR program grows. But even before you have gathered any additional information, your two lists should give you a relatively comprehensive picture of the toxic substances entering and leaving your facility, and of how much they are costing your business. In most cases, this will be enough information to permit initial discussion of cost-effective TUR opportunities.

Where To Look For Data

Chemical Input and Chemical Output databases have uses which extend far beyond TUR. For example, they may help you to improve control of your chemicals inventory and keep abreast of regulatory compliance.

Some companies may find that all of the information included in these two data-bases is already available in one central place -- perhaps in the purchasing or environmental engineering department. However, even if your company has not already assembled such data, the basic information you need should still be available on premises. The trick is to put your hands on it.

Your regulatory records are a good place to begin looking. Assign one or more team members to comb through these records in search of information about your use of toxics. If your firm emits enough toxics to be subject to federal SARA 313 reporting requirements, then your Form R report will have a great deal of the information you seek. If you are subject to TURA reporting requirements, then your Form S will also include detailed information about your toxics use, emissions, and byproducts.

Additional information about your RCRA hazardous wastes can be found by reviewing your manifest reporting records, while your POTW (Publicly Owned Treatment Works) or NPDES (National Pollutant Discharge Elimination System) permits will contain ready information on your water discharges. Finally, if you have a state DEP Air Source Registration, then your application records will include data on your air emissions.

Assign additional team members to mine other sources of data on toxics use. These might include purchasing records, Material Safety Data Sheets (MSDSs), stockroom and inventory records, delivery records, maintenance materials records, quality standards and customer product specifications, and/or process flow diagrams prepared by production engineers.

In addition, appropriate team members should gather rough information about purchase costs and treatment or disposal costs. This data will eventually be used to conduct a thorough financial assessment of the costs associated with your current production processes. (See Chapter 5.3, section 'a' "Listing Current Operating Costs")

Insuring Accuracy

In some cases, the information you gather at this stage will not be up to date, and will no longer accurately reflect your facility's production practices and toxics use patterns. You will have a chance to verify your data when you conduct a facility Walkthrough (Chapter 3.5).

The walkthrough is described at the end of the chapter because it serves as a chance to confirm the data you gather during other stages described in this chapter. However, you may wish to alter the order, conducting walkthroughs at earlier stages in order to check up on information as you gather it.

Your choice of a focus may also depend in part upon how much TUR experience you have already accumulated. For instance, if you are new to TUR, you may wish to select a project which is not terribly complicated or which will provide a good learning experience. Success in such a project could help solidify your company's commitment to TUR.

The twin data-bases developed above should prove helpful in your efforts to identify substances and processes which merit targeted attention. *Keep in mind that as you narrow your focus, you should revisit and sharpen your preliminary TUR goals* (see Chapter 2).

As you gather information, you should continually ask: "Why do we use the substance or process in question?"; "Where might processes be altered or substances substituted in order to reduce our use of toxic materials?"

TURA NOTE: So far, process characterization has been described in relatively informal terms. Companies subject to TURA reporting and planning requirements must meet more formal requirements. Specifically, they must analyze toxics use and consider possible use reductions in each of their "production units". A *production unit* is any process or combination of processes which produces a *product* -- where "product" may be defined very broadly to encompass *final products, intermediate products* (potentially saleable goods which are used to create other products), *results* (e.g. the cleaned clothes produced by dry cleaners), or *families of related products or results*.

These legal issues are discussed at greater length in Appendix 1. The important thing to note here is that, at least during this preliminary stage, it is not inconsistent with your TURA compliance efforts to focus your attention on a particular toxic substance rather than on a particular production unit. Once you have determined which production units are responsible for the most significant or most readily avoidable losses of this substance, then you can meet TURA's requirements by planning toxics use reduction changes for these production units.

Gathering More Detailed Information

Once you narrow your focus, you can begin to gather the more specialized data you will need in order to understand *all* of the various effects which the targeted substance or process has on your business and the environment. Until you have this sort of understanding, it will be difficult to evaluate proposed changes for possible adverse side-effects.

It is particularly important to understand the effects of the targeted process or substance on production techniques and processes, byproducts and emissions, product quality, worker health and safety, and the environment. You will also need as precise an idea as possible of purchase, treatment and disposal costs in order to assess the financial viability of proposed changes.

As you gather this additional information, you should keep a few key questions continually in mind: "Why do we use the substance or process in question?"; "What effects do these substances or processes have on public health, worker health and safety, and current or future environmental compliance?"; "Where might processes be altered or substances substituted in order to reduce our use of toxic materials or our generation of toxic byproducts?"; "How might we save money by optimizing production processes and the efficiency of chemicals use?"

FIGURE 3B: IN-PLANT DATA FOR PROCESS CHARACTERIZATION:

1. ENVIRONMENTAL RECORDS:
   a. SARA 313 Form R
   b. TURA Form S
   c. Manifest Reports
   d. POTW or NPDES Permits
   e. DEP Air Source Registration Records
   f. Laboratory Waste Analyses and Flow Measurements
   g. Responses to Past Government Surveys

2. PROCESS SCHEMATICS:
   a. Facility Blueprint
   b. Schematics of Storage, Processing and Shipping Areas
   c. Piping Diagrams
   d. Process Flow Diagrams or Other Process Descriptions

3. TECHNICAL DATA ON SUBSTANCES AND PROCESSES:
   a. Material Safety Data Sheets
   b. Maintenance Procedures and Records
   c. Production Line Scheduling Records
   d. Production Line Job Sheets, Batch Make-up Records and Mix Tickets
   e. Equipment Operating Manuals

4. TECHNICAL DATA ON PRODUCTS:
   a. Customer Specifications
   b. Quality Control Records
   c. Advertisements
   d. Product Data Sheets

5. OTHER BUSINESS OPERATIONS RECORDS:
   a. Chemical Inventory Records
   b. Chemical Delivery Records
   c. Chemical Purchasing Data
   d. Product Sales Records
   e. Waste Transporter Invoices
   f. Scrap Sales and Recycling Records

6. FINANCIAL RECORDS
   a. Departmental Cost Accounting Reports
   b. Treatment and Disposal Cost Records
   c. Chemical Purchasing Cost Records

In addition, it is critical to diagram periodic operations – such as equipment cleaning, maintenance and repair – which might use or produce toxic substances. You may have to create separate process flow diagrams to characterize these operations.

How To Create A TUR Process Flow Diagram

Your TUR diagram should include storage and handling phases which traditional diagrams omit.

The thinking behind your process flow diagram will depend to a large degree upon the kind of production unit you are analyzing.

For instance, conventional assembly-line processes are relatively easy to represent with process flow diagrams, as these processes are essentially linear, with raw materials coming in one end and products coming out of the other. The final diagram can be laid out in the same configuration as the factory floor, and a quick visual check of the actual production line can often ascertain whether any step has been omitted.

Other processes may prove more difficult to diagram. For instance, you may have targeted a "batch process", in which the various processing steps occur in a single place on the factory floor. In this sort of case, where processing steps are separated temporally rather than spatially, you must do some careful analytical thinking to ensure that your diagram captures each step necessary for converting incoming raw materials, energy, and labor into products and residual byproducts.

Whatever type of process you are analyzing, your final diagram should look roughly like a blueprint of a traditional linear assembly process. In most cases, your diagram should take the form of a line of boxes, each labeled to indicate the production step it represents, and each connected to other boxes in a sequence which parallels the production sequence.

The raw materials which enter the process should be arrayed on one side of this line of boxes, with lines indicating the point at which they enter. All products and byproducts should be arrayed on the other side of the line of boxes, with lines indicating the point at which they leave the production unit.

The sample process flow diagram in Figure 3C represents a nickel-plated paper clip manufacturing process. Work flows down the page, from the first process (Wire Drawing) to the last (shipping). Pre-production storage and handling steps are diagrammed in the second column, while box #11 represents post-production storage of finished products.

TURA NOTE: Under TURA, production units are defined in a very flexible manner. Any process or combination of processes which produces a desired result or product (whether finished or not) could count as a separate production unit. Thus, the process diagrammed in Figure 3C could be counted as more than one production unit. For instance, since unplated paper clips might be sold to a plating shop for completion, steps #1-4 could constitute an independent production unit.

TURA also requires each toxic substance used in a given facility to be tied to all production units in which it is used (except for toxic chemicals used to treat toxic byproducts). For instance, if the degreasing unit represented by box #4 in Figure 3C were used in other production processes, then trichloroethylene use would have to be attributed to more than one production unit.

TURA plans must contain a process flow diagram for each production unit in the facility. See Appendix 1 for more information.

The Chemical Pathway Analysis

If you have chosen to target your TUR efforts on a production process, you should now have in hand a process flow diagram representing that process. If you have targeted a substance, you should have diagrams representing the principal processes in which it is used.

Either way, it is time to use these diagrams to create *chemical pathway analyses.* The purpose of a chemical pathway analysis is to track the flow of a toxic substance through a process. This will give you a graphic idea of the fate of each toxic chemical under consideration.

A chemical pathway analyses will permit you to track a toxic substance from the moment it enters your plant to the point at which it leaves – while helping you to locate all of the points at which it may become a byproduct along the way.

If you have targeted a process, you should create a separate pathway analysis for each major toxic chemical used or produced by the process. If you have targeted a substance, you should create a separate analysis of the chemical's pathway through each of the processes in which it is used.

Your chemical pathway analyses will permit you to track a given substance from the moment it enters your plant, through a given production process, to the time when it leaves the process as a product or residual byproduct, and even to the point it leaves your plant. This can help you to locate all of the points at which portions of the chemical may become a byproduct, reducing efficiency and perhaps causing a threat to worker health and the environment.

How To Create A Chemical Pathway Analysis

To create a chemical pathway analysis, begin with a photocopy of the relevant process flow diagram. Now take a pen and trace the chemical from the point at which it enters the process to the point or points at which it leaves. In many cases – particularly if you are dealing with a volatile chemical – you will find that the line branches in several places as trace amounts of the chemical are released to the environment, or as portions of the substance enter into chemical reactions and give rise to new products and/or byproducts.

Your TUR process flow diagram should include pre-process storage and handling and post-process handling and treatment. If it does not, then you should expand your chemical pathway analysis to include these stages. In so doing, be sure to use branching lines to indicate all possible losses, including losses due to spills and evaporation.

A Sample Chemical Pathway Analysis

The following chemical pathway analysis tracks the pathway of Nickel Plating bath through the metal plating portion of the paper clip manufacturing process diagrammed in Figure 3C:

However, you should keep an open mind about TUR alternatives until your team has carried out the formal options generation procedure described in Chapter 4.

Aside from its importance in identifying TUR options, this materials accounting process will serve as the basis for measuring the success of your TUR process changes. If you do not determine the volume of toxic byproducts which you start with, there will be no way of determining how effectively those byproducts have been reduced.

This section begins with a discussion of some rudimentary materials accounting techniques aimed at gaining a qualitative picture of your byproduct generation patterns. These rudimentary techniques require little time and use readily available data, yet may be sufficient to permit you to identify TUR opportunies. The section ends with a discussion of a more complex materials accounting tool -- the mass balance -- which requires more time and greater expertise. A mass balance can provide precise, quantitative measurements of byproducts volumes which sometimes prove instrumental in identifying TUR opportunities and which are needed in order to make accurate measurements of TUR progress.

Once you have calculated the amount of the toxic substance which you are using and the amount which is contained in your product, you can determine your total byproducts with simple arithmetic.

Rudimentary Materials Accounting

You should do a separate materials accounting for each substance/process combination you are looking at. In each case, the first task is to estimate the total amount of the toxic substance which ends up as a byproduct or emission of the process under consideration.

You can calculate the magnitude of the substance which ends up as a *byproduct* by determining the amount that you use and subtracting from it the total amount that ends up in your product or is changed into a non-toxic substance by a chemical *reaction*:

Byproduct = Use - (Product + Converted in Reaction)

This formula will give you the volume of byproducts as defined under TURA. Under this definition, there is no need to measure emissions in order to calculate byproducts. This is because all emissions -- even those which are released directly from the production unit into the environment -- are regarded as byproducts first, before they become emissions.

The 'product' in question here need *not* be a *final* product of the sort which you sell to your customers. For instance, you may be analyzing a production process that creates parts which are used to fabricate a final product. In that case, the "Product" factor would represent that portion of the toxic material under investigation which ends up in usable parts.

The information your team has collected at earlier data-gathering stages should help you to derive a rough estimate of the amount of the toxic substance which you are using and the amount which is contained in your product. If you are considering a substance which reacts with other chemicals during the process, creating non-toxic byproducts, then you may need a chemical professional to help you estimate the amount which is being lost in reaction.

General information about toxics use should be contained in the Chemical Inputs Database described in Chapter 3.1. Keep in mind, however, that this database contains information about your *aggregate* use of each chemical in your plant; it may not tell you how much of the toxic is being used in the particular process under consideration. To derive a loose estimate of this more specific magnitude, you should review raw material purchasing, delivery and storage records, internal materials transfer records, and factory floor records such as job sheets and mix tickets.

The data which your team has gathered may help you to make these sorts of quantitative assessments. For instance, if you have run laboratory tests on your air emissions, water discharges or solid wastes, then these test results can be used.

Regulatory records may also provide valuable information about the quantities and concentrations of various emissions and wastes. Since emissions are nothing more than byproducts which have left your plant, this data can be quite helpful. However, since your emissions often come from several production units at once, emissions data may not be specific enough for your TUR needs.

One of the keys to a successful TUR program is the development of accurate and complete data on toxics use, emissions, and byproducts.

There may also be standard industry measures which can be used to make sound quantitative estimates of byproduct magnitudes. For instance, there are figures for calculating evaporative losses from degreasers caused by variations in cooling coils, covers and hoist speeds. Similarly, there are standard equations which can be used to calculate losses of electroplating solutions due to drag-out, evaporation and spills.

These sorts of standard industry measures are sometimes available from industry trade groups, chemical suppliers, and chemical engineering reference materials. *If you have trouble finding this sort of information, or have other difficulties analyzing your processes, you can get professional help by contacting OTA at (617) 727-3260.*

Conducting a Mass Balance

One of the keys to a successful TUR program is the development of accurate and complete data on toxics use, emissions, and byproducts. Such data will permit your team to spot TUR opportunities and to measure and document TUR progress.

One useful technique for improving your materials accounting data is the *mass balance*. However, because mass balances are rather difficult and time-consuming, you may wish to conduct them only for the most critical production units.

The aim of a mass balance is to determine the eventual fate of all of the chemicals which enter a given production unit during some determinate time period. The total mass of these material inputs must be accounted for either as byproducts, products, or materials accumulated in the production unit. The appropriate equation is:

Material Inputs = Byproducts + Products + Accumulated Materials

Before this calculation can be attempted, the production unit must be defined carefully. For analytical purposes, the production unit can be thought of as surrounded by an imaginary envelope. The task, then, is to account for all materials which enter the envelope (i.e. raw materials) or leave the envelope (i.e. byproducts and products) during the time period set for the mass balance calculation. Remember: emissions are a subset of byproducts.

At the end of the period, the amount of material accumulated within the production unit should be measured. The numbers can then be plugged into the formula given above. Any discrepancy in the resulting equation represents either measurement errors or unaccounted-for materials. If inputs are far larger than outputs, further research may be needed to identify previously unrecognized sources of byproducts.

The time period set for the mass balance should be a *representative* period. That is, the operations and processes standardly associated with the production unit should all be performed during the period for typical portions of the total time. If not, the entire exercise will not provide an accurate picture of the process in question.

byproducts may be created – including shipping and receiving docks, storage areas, and in-house treatment and recycling sites. While at these sites, interview workers who handle and transport toxic materials to insure that they are properly trained and that they follow sound housekeeping practices.

Do not skip an area simply because you already know it well. You must look at everything as if you have never seen it before, carefully reconsidering each part or stage of each production process.

If your team has already come up with some preliminary TUR suggestions, make a list of them and distribute a copy to each member of the team. This will permit you to discuss their feasibility with workers and other team members as you examine the relevant processes first-hand. You should also photocopy and distribute all of the process flow diagrams and chemical pathway analyses which your group has prepared, so that they can be checked against actual production practices during the walkthrough.

Finally, be sure that the entire team wears whatever safety gear is appropriate for the areas of the plant you will visit.

Input from workers can be invaluable in determining how equipment in your plant really operates. When in doubt, ask why things are done the way that they are.

Carrying Out The Walkthrough

The overall purpose of the walkthrough is to subject each detail of your production operations to fresh scrutiny. As you examine each production step, ask yourself why it is done the way it is, and how it might be changed to reduce toxics use.

During the walkthrough, team members should check your actual processes against your group's process flow diagrams and chemical pathway analyses. Often, production units have been modified so that they no longer operate as described in the original operating manual. Make sure that your diagrams correspond to reality, and modify them where incorrect.

Input from workers can be invaluable in determining how equipment in your plant really operates. When in doubt, ask why things are done the way that they are. It is important to understand the human dimensions of your production practices so that you can avoid changes which workers will find impracticable.

It is particularly important to keep your eye out for sources of byproducts which are not represented on your diagrams. Pay attention to fumes and odors which might indicate that toxic materials are escaping. Look for possible sources of leaks, spills and evaporative losses.

Some toxic byproducts will not be readily apparent, even during a walkthrough. For instance, unless you schedule your walkthrough on cleaning day, you may not actually see spent cleaning fluids being produced, even though such fluids can sometimes count as a toxic byproduct. Be sure to ask workers about equipment cleaning and maintenance procedures. If necessary, revisit the production unit when they are being carried out.

Walkthroughs often lead to a number of preliminary conclusions about where toxics are being lost and what might be done to reduce toxics use. As you ponder alternatives, keep in mind the full range of TUR methods: product reformulation, input substitution, process modernization, process redesign, operations and maintenance improvements, and in-process reuse and recycling. (These are described in greater detail in Chapter 4.) Remember also that worker interviews can be invaluable sources of new ideas.

As ideas are generated, add them to your group's list of TUR alternatives. Use the walkthrough to begin to evaluate the feasibility of these possible changes. With the production processes right in front of you, it is easier to visualize the possible side-effects of each proposal on workers, equipment and other production processes.

Chapter 4: Identifying TUR Options

4.0: Identifying TUR Options -- An Overview

At this point, you have developed a graphic understanding of toxics use patterns in your plant. You have identified some of the costs of using toxics, located the points at which you lose toxic materials, and determined which of these losses are most significant – perhaps even quantifying them. You may also have begun to develop a few ideas about process changes which would reduce your reliance on toxics.

Now your TUR planning efforts enter the creative phase. The object of this phase is to generate as complete a list as possible of alternatives for reducing your use of toxics and/or your creation of toxic byproducts.

This chapter describes a brainstorming process designed to elicit input from as many team members as possible, so that your TUR options will reflect a variety of perspectives and areas of expertise. The brainstorming process is structured to insure that your team considers all possible types of TUR.

Of course, it is not *always* necessary to go through a formal options-generation process such as the brainstorming session described in this chapter. You may already be convinced that you know what needs to be done. In that case, all that remains is to implement the change.

However, the most typical mistake at this phase is to settle for an inadequately small list of options. Keep in mind that *the more options you consider, the more likely you are to select the one that is best for your plant.*

4.1: In-House Brainstorming

It is not easy to specify one options-generation procedure appropriate for all businesses. After all, each business has a different corporate culture and different decision-making practices. However, it is strongly recommended that you *begin* your search for TUR options with a group brainstorming session.

Group brainstorming is designed to elicit input from all team members and encourage creative thinking. Since TUR brainstorming is very similar to the brainstorming done by quality circles, many businesses will find it quite familiar.

4.2: The Six Kinds of TUR

TUR can be achieved by a great variety of means, ranging from complete production unit redesign to simple changes in work habits and toxics handling methods. Massachusetts state law classifies these various methods into six generic *kinds* of TUR options.

As noted above, you can insure that your search for TUR options is comprehensive by organizing your brainstorming so that you consider each of these kinds of TUR options in order. If you turn to outside consultants for further help in generating TUR options (Chapter 4.3), you should make sure that these consultants also consider the full range of TUR options.

It is not TUR if you merely shift your toxic emissions from one medium to another, but fail to reduce overall toxic byproducts.

Figure 4A outlines the six kinds of TUR as specified under Massachusetts law.

FIGURE 4A: THE SIX KINDS OF TUR UNDER STATE LAW

1. **Input Substitution**: If the toxic in question is used in the production process rather than in the product itself, it is sometimes possible to replace it with a less toxic or non-toxic alternative.

2. **Product Reformulation**: TUR can sometimes be achieved by reformulating a final product so that the product is less toxic or non-toxic upon its use, release or disposal.

3. **Process Redesign**: Toxics use or byproduct generation can sometimes be reduced or eliminated by developing and using production machinery of a different design than the machinery currently in use.

4. **Process Modernization**: TUR can sometimes be achieved by upgrading or replacing production machinery with other equipment and methods based upon the same production technology.

5. **Improved Operations and Maintenance**: TUR does not always call for sophisticated technological innovation. Improvements in inventory control, materials handling, spill and leak prevention, personnel training, and/or maintenance practices can often lead to dramatic reductions in the use of toxics or the generation of toxic byproducts.

6. **In-Process Recycling and Reuse**: TUR can also be achieved by in-process recycling and/or reuse of toxics. TUR recycling units must be integral to the production process.

TUR product reformulation may permit your company to boost sales by tapping into the growing consumer demand for "green" products.

FIGURE 4B: EXAMPLES OF TUR PRODUCT REFORMULATION

1. The paint manufacturing industry has made considerable headway in replacing toxic mineral spirits-based paints with alternative water-based formulas. (Note: Not all water-based paints are non-toxic. It is important to make sure that the new formula, however benign it sounds, is truly less toxic than the old.)

2. Paint manufacturers have also reformulated their products to eliminate heavy metals such as the titanium traditionally used in white paints and the cadmium traditionally used in yellow paints.

3. Some ink manufacturers have introduced water-based inks as an alternative to traditional solvent-based inks.

4. There is a cutting-edge trend in the plastics industry to develop biodegradable vegetable-based plastics as an environmentally sound alternative to traditional petroleum-based plastics.

5. Sometimes, product reformulations can eliminate a toxic indirectly. For instance, some metalworking manufacturers have eliminated toxic cleaning and painting processes by making metal parts out of stainless steel. Such a change might be classified either as a product reformulation or as a process redesign.

Input Substitution The next kind of TUR for your team to consider is input substitution. The operative question here is *Could any toxic raw materials be replaced with benign or less toxic substitutes?*

Input substitutions can be very attractive, as they can dramatically reduce your liability exposure and alleviate your environmental compliance headaches. They might also cut your raw material purchase costs and disposal fees.

Figure 4C provides some real-world examples of input substitution.

A process redesign changes your fundamental production technology, introducing new production machinery of a different design than your current machinery.

FIGURE 4D: EXAMPLES OF TUR PROCESS REDESIGN

1. A good example of a process redesign – one applicable to such industries as metalworking and electronics – is the replacement of a solvent-based paint stripping unit with a unit which strips paint with reusable abrasive blast media.

2. A second example – this one from the textiles industry – is the replacement of an old-fashioned dying machine with a computerized dying operation which conserves heavy-metal dyes.

3. Some pulp mills have achieved TUR process redesign by installing ozone bleaching processes, thus eliminating their use of chlorine in the bleaching process.

4. Some metal platers have installed automatic barrel lines which permits greater control of plating processes. Used with environmental ends in mind, such a line can significantly reduce the drag-out of heavy metals.

5. Sometimes, process redesign can go hand-in-hand with other TUR techniques. For instance, the abrasive blast unit described above (example 1) involves an input substitution, for it effectively replaces solvents with reusable blast media.

6. Process redesign might also go hand-in-hand with materials reuse (described below). For instance, some printers have extended the life of their acid etchants up to tenfold by installing specialized equipment to monitor and continually reconstitute their etchant baths. Similarly, some chemicals and paint manufacturers have installed high-pressure wash systems or automatic squeegee systems to clean away and reuse mixing tank residues.

4. Process Modernization: Significant reductions in toxics use can often be achieved by upgrading or replacing production equipment to achieve greater production efficiency. Where these changes do not involve a redesign of the production unit, they fall under the heading of process modernization.

When pondering process modernization techniques, your team should keep the following question in mind. *Are there ways to alter, adjust, modify or replace existing production equipment in order to cut toxics use and/or toxic byproducts?*

Process modernization is actually a rather broad term, encompassing at least two different sorts of changes. *First*, it can include minor alterations or adjustments to existing production companies which have yet to pay much attention to their toxics use patterns, dramatic reductions – sometimes as high as 50 percent – can be achieved simply by improving operations and maintenance practices. This can mean bottom-line savings without major up-front costs.

At this stage in your group brainstorming, the operative question is: *How might we reduce the needless waste of the toxic substances we store, transport, handle and use?*

In most companies which have yet to pay much attention to their toxics use patterns, dramatic reductions – sometimes as high as 50 percent – can be achieved simply by improving operations and maintenance.

Improved operations and maintenance is a low-tech method for reducing toxics use. It requires relatively little technical research, and does not tend to have a great number of side effects.

All of this does not imply that it is *easy* to improve operations and maintenance practices. Work habits can acquire a great deal of inertia. As a result, successful changes require concerted and sustained commitment from workers and managers alike.

Like process modernization, improved operations and maintenance is a broad category, encompassing several sorts of TUR changes. *First*, improved operations and maintenance can mean tighter controls of chemical inventories. *Second*, it can include improvements in materials handling practices – both during the production process itself, and during the loading, unloading and storage phases which precede and follow the process. *Third*, it can mean changes in the equipment operations and maintenance practices.

The following figure gives examples of the various sorts of changes which can count as improved operations and maintenance.

team to consider here is: *Can any of our toxic byproducts be recycled and/or reused without leaving the production process?*

It is important to note that not all recycling counts as Toxics Use Reduction. Under Massachusetts law, recycling only counts as TUR if it is done in-process, by a recycling unit which is integral to the production unit in which the toxic substance is used.

The reason for this requirement is that off-site or out-of-process recycling requires additional handling and transportation of toxics – either within a factory or between two plants, via public highways. This additional handling and transportation can pose a threat to the safety and health of the public and/or workers. Thus, while recycling toxic substances is usually better for the environment than simply discarding them, it is not the sort of optimum solution which TUR encourages.

Some examples of TUR recycling are offered in the following figure.

Under Massachusetts law, recycling only counts as TUR if it is done in-process, by a recycling unit which is integral to the production unit in which the toxic substance is used.

FIGURE 4G: EXAMPLES OF TUR RECYCLING AND REUSE

1. One newspaper printing operation found it profitable to recycle its waste inks, adding black toner and ink to reconstitute them as usable black ink. (This is TUR under the law if the recycling is integral to the process.)

2. A number of metalworking companies have begun to recycle their cutting oil by installing closed-loop collection sumps into which spent oil can be skimmed of soils, treated with biocides, and returned to the process.

3. A common recycling technique, applicable to a number of industries, is the installation of a hard-pipe solvent still which is capable of restoring spent solvents by extracting oil sludge.

4. Many metal platers have found that by increasing the concentration of metal plating solutions in rinse tanks – perhaps by restricting water flow – they can reuse rinsetank contents as make-up plating solution.

Attleboro-based electroplater with 11 employees, was ordering metal parts from Southeast Asia. The manufacturer covered these parts in grease to prevent tarnishing during shipping, and Reliable removed the grease with solvents before using them. The firm eventually became aware that when the cost of degreasing was added to the cost of the imported parts, they were as expensive as comparable parts made by local manufacturers. Reliable switched to a local supplier whose parts arrived clean of grease, thus cutting its solvents use in half.

(b) Solvent Substitution

Ask yourself: Do we really need to clean as much as we do? Are there alternative production processes which do not require extensive parts cleaning? Are there things we currently clean with solvents which could be cleaned some other way?

When cleaning operations cannot be eliminated altogether, the next best alternative -- particularly from a worker safety standpoint -- is solvent substitution. This technique is applicable to a wide range of industrial cleaning and stripping operations spanning such industries as printing, plastics, metals finishing and manufacturing, electronics, vehicle manufacturing and aerospace.

Solvent substitution can help to rid your workplace of toxic vapor degreasers -- the most common of which are trichloroethylene, perchloroethylene, methylene chloride and 1,1,1-trichloroethane. Many common vapor degreasing operations can be carried out with readily available water-based cleaners.

These new aqueous cleaners typically contain rust-inhibitors and highly effective organic surfactants which clean immersed metal parts without retaining contaminants in the cleaning solution. Oils float to the top of the cleaning tank and can be skimmed off; soils sink to the bottom and can be removed by filtration. In some cases, the result is an almost indefinitely reusable cleaner.

There is no foolproof formula for choosing an appropriate solvent substitute; the choice will depend upon the material you are cleaning, the nature of the contaminants, and the technical demands of your production process. OTA can provide information about aqueous-based cleaners, including case studies of successful applications and lists of suppliers. Call OTA at (617) 727-3260 for more information.

(c) Solvent Minimization

As long as your plant continues to use any solvents at all, you should pursue low-tech changes in your work practices which can help to minimize your use of these solvents.

You might begin by examining your solvent tanks to make sure that they are designed to minimize solvent use. For instance, each tank should be fitted with a cover which should be kept in place when the tank is not in use. This alone can cut evaporation by as much as 50%. You can also cut evaporation by using a deep, narrow tank with a small solvent surface area and a high freeboard (area above the vapor level). Another method is to add cooling coils for increased vapor condensation.

By pulling parts from the tank more slowly, you can cut the amount of solvent "dragged out" of the tank. If you have an automated cleaning tank, you may be able to reduce drag-out further by adjusting it so that parts are held above the solvent bath and drained after they are withdrawn. (If your tank is operated manually, this same technique could pose a threat to worker health.) And if you spray solvents, you can cut evaporative losses by using a coarse stream rather than a very fine spray.

You might also wish to ask yourself a number of questions about your cleaning practices. For instance: Are there parts cleaned in vapor degreasing tank which could be cleaned with set up a central station for recycling coolants by filtering and coalescing tramp oils. The equipment cost $20,000 to install, and has resulted in annual savings of $8,000 in coolant purchase costs, $10,000 in coolant disposal costs, and $8,800 in machinery down-time.

Improved coolants management can help a wide range of metal working companies to reduce their liability exposure and tool replacement costs, cut their coolant purchase and disposal costs, and improve the workshop environment by eliminating rancid coolant odors.

On the other hand, poor coolant management can lead to a number of problems. For instance, if coolants are not properly maintained, bacteria can breed in dead spots within the machinery, where grit and sludge build up. Valuable production time and dollars can be lost in replacing coolants. Poorly maintained coolants can increase tool breakage and decrease product quality. In addition, frequent disposal of spent coolants can often lead to violations of effluent discharge limits.

Improving coolants management can help reduce liability exposure and tool replacement costs, cut coolant purchase and disposal costs, and eliminate rancid coolant odors.

There are a number of proven techniques for improving coolants management, including: (a) coolant substitution; (b) coolant recycling; and (c) improved coolant maintenance. These methods can often increase the life-span of coolants by two to threefold.

(a) Coolant Substitution

Due to recent advances in emulsion technology, straight petroleum oils can in many instances be replaced with water-based coolants. These new coolants are made from emulsions containing high-pressure additives and lubricity packages.

Initial purchase costs of these emulsions may seem higher, but once diluted to proper working concentrations, these water-based coolants can be as much as 50% less expensive. They can also usher in reductions in waste oil disposal costs and liability risks, while reducing your use of solvents for cleaning hands and degreasing parts and machinery. In a situation where large quantities of coolant are being replaced, this can amount to a significant savings.

Switching to an emulsion coolant can eliminate oil mist and smoke, improving operating conditions across the shop floor. Many facilities have been able to increase their speeds and feeds after converting to water-based coolant. This is due primarily to the better heat-transfer properties and lower viscosity of the water-based coolants. Increased production rates spell further savings in machine and labor time.

(b) Coolant Recycling

Coolant recycling techniques can stretch the life of coolants dramatically while helping to extend tool life, improve product quality, decrease purchase and disposal costs and improve working conditions for employees.

There are many technologies available for recycling coolants. One of the best techniques is to reclaim coolants through a combination of particle filtration and centrifugal separation. Filtration can be used to eliminate the larger metal chips created by grinding, milling and other processes, while centrifugation can remove remaining metal fines as well as hard-to-extract emulsified oils and some bacteria.

The best place to install metal chip screens is at the coolant entrances to work station sumps. Larger end-of-pipe screens can be placed at the central collection tank if coolant sumps cannot be modified.

If your coolants are contaminated by floating tramp oils, these can be removed by using a belt or disc skimmer. Belt skimmers have the advantage of depositing waste oils directly

3. METALS USE REDUCTION IN PLATING LINES

Howard H. Sweet & Son, Inc., an Attleboro jewelry manufacturer with 125 employees, responded to growing regulatory pressures in 1985 by investing in a virtually closed-loop metals recovery system which dramatically reduced its toxic byproducts. The system, which recovered 263 troy ounces of gold and more than a ton of copper in the first year, paid for itself in less than 12 months and henceforth saved the firm more than $100,000 per year.

Another Attleboro-based silver plating firm has employed a metals recovery system to reclaim more than $100,000 per year of silver dragged out of its plating solution.

These firms are two of a growing number of jewelers, metal platers and printed circuitboard manufacturers which have used TUR techniques to reduce the concentration of heavy metals in their wastewater while simultaneously saving on metals purchase, treatment and disposal costs.

Metals minimization techniques can be broken down into three general categories: (a) water conservation, (b) plating solution recovery; and (c) metals reclamation.

By using less rinsewater, dragged-out metals can be concentrated in a smaller volume of water, making it much easier to recover metals or reuse metal plating solutions.

(a) Water Conservation

Since water is not toxic, water conservation does not itself count as toxics use reduction. However, in many cases water conservation is the first step toward effective metals recovery. By using less rinsewater, dragged-out metals can be concentrated in a smaller volume of water, making it much easier to recover metals or reuse metal plating solutions.

There are a number of simple ways to conserve on rinsewater. One of the easiest ways is to install so-called "drag-out" tanks (still-water rinse tanks, as opposed to running rinse tanks) immediately after the plating bath tank and before the running water rinse-tanks. This insures that parts enter the running rinsewater cleaner, with fewer contaminants.

Rinsewater can also be conserved by placing flow-restrictors on running rinses, and by using "counter-current rinsing". The idea behind counter-current rinsing is to connect running water rinsetanks so that rinsewater flows through each of them in sequence -- in the opposite direction of production line work -- before being discharged as wastewater. The relatively clean rinsewater from the final tank is thus reused in earlier rinsing stages.

Before any attempt is made to recover metals from rinsewaters, all efforts should be made to prevent plating solution from "dragging out" into rinsewater to begin with. Some common techniques for managing drag-out can be found below, in the section entitled "Life Extension of Chemicals and Chemical Baths."

Ion exchange technology uses natural or synthetic resins which can recover high percentages (90-95%) of chromium, gold, silver, tin and zinc from spent rinsewaters. Ion exchange units are quite durable, use little energy and work with relatively dilute rinsewaters. If you wish to install an ion exchange unit, make sure that you choose the resin appropriate for your application, and that you install a carbon filter before the ion exchange unit so that it does not become fouled with organic contaminants.

It is a generic TUR principle that chemical bath life should be extended wherever possible through such techniques as drag-in and drag-out management, improved bath maintenance and bath regeneration.

Focus: Metals Reclamation at Work

Hi-Tech Gold Plating Corporation, an 8-worker plating jobshop in Worcester, MA, implemented a metals reclamation program in order to cut the amount of metals it discharged into the sewer.

After introducing counter-current rinsing on all plating lines, thus reducing water consumption by 75%, Hi-Tech fitted each of its lines with an electrolytic metals recovery units. Initial results indicate that the electrolytic units have cut metals discharges by more than one third.

The economics of Hi-Tech's process changes are rather attractive. The changes, which cost approximately $2,900 to implement, will save the firm approximately $2600 per year in water bills while netting it an additional $100 per year in scrap metal sales. Based on these initial figures, the investment will pay for itself in just over a year.

4. LIFE EXTENSION OF CHEMICAL BATHS

IBM has extended the life of ammonium persulfate etching bath by devising a protocol for the addition of fresh etchants in order to maintain constant and precise pH levels. IBM has also begun to regenerate spent acid etchants by bubbling ozone through them to reverse the oxidation/reduction reaction which normally strips the etchant of oxygen. As a result, toxic etchant baths which were once discarded every 12 days have been in continuous reuse for several years, and have come to be known among IBM engineers as "immortal etchants." Tens of thousands of dollars have been saved in etchant purchase costs. And because parts are no longer etched poorly in the period immediately before baths are discarded, IBM has significantly reduced the number of parts which must be rejected, netting another $4.5 million in savings.

The "immortal etchants" case is one particularly dramatic example of a generic TUR principle: where possible, extend the life of chemical baths. This can be done by a variety of means, including (a) drag-in and drag-out management; (b) improved bath maintenance; and (c) bath regeneration

(a) Drag-In and Drag-Out Management

"Drag-out" refers to chemical solutions dragged out of a bath together with the parts or materials treated in the bath. "Drag-in" refers to chemicals which enter a chemical bath with the parts or materials treated in it. Together, drag-out and drag-in can quickly deplete or

(c) Bath Regeneration

The life of many chemicals can be extended by adding reagents, stabilizers and other key components when needed. For instance, fixing baths used in the commercial printing industry can be stretched by adding ammonium thiosulfate, which makes the bath effective at higher silver-saturation levels.

Chemical baths can also be sustained through a variety of filtration techniques. In-tank filtration is particularly safe and effective, as it does not interrupt production processes, nor does it give rise to the spill and leak potential associated with out-of-tank filtration. There are a wide array of relatively inexpensive ($400-$1400), commercially available in-tank filters – some of which perform such additional functions as bath treatment, agitation, surface contaminant skimming and tank bottom vacuuming.

Many companies underestimate the amount of toxic substances which escape into the factory environment during storage and handling, due to such factors as leaks, accidental spills and evaporation from improperly stored chemicals.

If you install a filter, make certain to use the filter cartridge most appropriate for the application at hand. For instance, it is usually best to use the coarsest filter which can remove the common contaminants in your bath, as these filters will last longer and permit greater flow rates. If you are filtering out organic compounds, it may be best to opt for a carbon filter which will minimize organics build-up.

In many cases, filters should be run even when the bath is not in use, as impurities are often dragged in more rapidly than filters can remove them.

In addition to filtration, there are a variety of other means for removing impurities from chemical baths. For instance, commercial printers can reclaim and sometimes reuse their fixing baths by using an electrolytic recovery unit to remove silver from it.

Similarly, spent etchants can be regenerated and reused by a number of processes – including electrolytic removal of waste metals. If you are discarding such etchants, you may wish to look at the costs of make-up chemicals for the baths, pH balancing chemicals to stay in compliance with discharge limits, and the value of metals which might be extracted from your spent etchants and sold back to a metals reclaimer. These figures often underline the economic wisdom of investing in an etchant reclamation system.

5. GOOD HOUSEKEEPING

Many companies underestimate the amount of toxic substances which escape into the factory environment during storage and handling. Slow leaks, accidental spills, and evaporation from improperly stored chemicals can add up to significant losses. These losses are not only costly and inefficient – they may also pose a threat to worker health and safety.

Often, simple and dramatically effective TUR can be achieved by introducing sound chemical housekeeping practices. Good housekeeping is a form of TUR which applies to all toxics users – regardless of their size or line of business. It can include: (a) improved chemical inventory management; (b) improved storage and handling practices; and (c) spill and leak prevention. These goals can sometimes be promoted by employee training programs and by introduction of incentives for clean practices.

This is one of many areas in which worker cooperation can be critical to your TUR efforts – and one more reason to include workers on your TUR team.

FIGURE 4H: COMMON TUR TECHNIQUES

1. CLEANING ALTERNATIVES:

(a) Elimination of Cleaning Operations: Clean fewer materials.

(b) Solvent Substitution: Replace organic solvents with aqueous-based cleaners.

(c) Solvent Minimization: Cover tanks. Minimize solvent surface area. Use high freeboard. Remove parts slowly and drain well. Consider two-stage cleaning process.

(d) Solvent Recovery: Use solvent distillation or other method (decantation, filtration, evaporation, centrifugal purification). Consider vapor recovery.

2. COOLANT ALTERNATIVES:

(a) Coolant Substitution: Replace oil coolants with water-based coolants.

(b) Coolant Recycling: Consider centrifugation, filtration, oil skimming and chip spinning.

(c) Coolant Maintenance: Conduct thorough machine cleaning and regular pumping of sumps. Maintain coolant-water ratios. Consider ion exchange.

3. METALS USE REDUCTION IN PLATING LINES:

(a) Water Conservation: Use drag-out tank and counter-current rinsing.

(b) Plating Solution Recovery: Use direct drag-out return. Consider cold vaporization. Aim for closed-loop plating.

(c) Metals Reclamation: Consider electrolytic recovery and/or ion exchange.

4. LIFE EXTENSION OF CHEMICAL BATHS:

(a) Drag-In and Drag-Out Management: Achieve lower surface tension. Reduce viscosity. Install drag-out tank, drip boards, baffles, etc. Remove parts slowly and drain well.

(b) Improved Bath Maintenance: Monitor solution purity, pH, temperature and other parameters. Consider mechanical agitation.

(c) Bath Regeneration: Use reagents, stabilizers and other additives. Consider filtration, electrolysis and/or other bath regeneration techniques.

5. GOOD HOUSEKEEPING:

(a) Chemical Inventory Management: Buy chemicals as needed. Use in order received.

(b) Improved Storage and Handling: Minimize traffic and maintain proper storage conditions. Train workers in materials transfer.

(c) Spill and Leak Prevention: Replace leaking equipment throughout plant. Train workers and offer incentives for spill minimization.

Chapter 5: Evaluating and Selecting TUR Alternatives

5.0: Evaluating and Selecting TUR Alternatives -- An Overview

Your team has now generated a comprehensive list of TUR alternatives for the substances and/or processes under consideration. The next step is to evaluate these options and select one or more for implementation.

This chapter presents an evaluation method which begins with a series of "screens" which any option must survive in order to be considered truly feasible. The point of these screens is to limit the number of full-fledged analyses which your team will have to do, as such analyses are time-consuming. However, it is important not to eliminate options too hastily. In many cases, successful TUR requires a creative exploration of options which seem impractical at first glance.

At any rate, once the field of alternatives has been narrowed, you can submit the remaining TUR proposals to a more detailed scrutiny, examining their technical merits and compatibility with managerial goals and worker practices. Most TUR teams will also wish to submit competing proposals to a detailed financial analysis in order to determine whether up-front expenditures are economically justified. An adequate financial assessment may require, among other things, a detailed evaluation of costs which many firms lump together under the generic heading "overhead." Part 3 of this chapter describes such an assessment technique.

As these evaluations are carried out, it will start to become clear whether the provisional TUR goals which your team has set (Chapter 2.3) are either overly ambitious or overly modest. You may wish to firm up your goals as you see what kind of improvements are feasible at your plant.

The evaluation process recommended in this manual is outlined in Figure 5A. Each of the steps is discussed in greater detail in subsequent parts of this chapter. Of course, the particular series of screens and evaluations outlined in this chapter might not be appropriate for every company. Your team may wish to modify the process by adding or subtracting criteria to reflect your firm's environmental goals and business objectives. You may also wish to assess your processes using the same criteria that will be used by upper management to decide whether the project should be funded.

5.1: Screening TUR Options

Before your team meets to begin assessing TUR alternatives, it may be wise to give each team member a list of all options under consideration, together with a copy of Figure 5A. This should provoke thought about the feasibility of various TUR alternatives, helping to make your first options assessment meeting as fruitful as possible.

Your team probably will not be able to complete the evaluation of all options and select a course of action in one sitting. A thorough technical and financial evaluation of the most promising options will usually require considerable research. The goal of your first options evaluation meeting should be to screen out unacceptable options and narrow your list of alternatives to those which are most deserving of further attention.

You might find that some options are so straightforward, inexpensive, effective and easy to implement that no further assessment is needed in order to approve them.

As you narrow the list of candidate TUR changes, you should be able to determine what data you will need to complete your assessment and choose a course of action. Appropriate team members can be assigned to secure this information and report back to the group.

It is also a sound idea to keep a permanent record of the options which you consider, and of your reasons for rejecting those which you do not implement. This may help you to avoid reinventing the wheel in future years, as your TUR program grows.

Options Pre-Screening

The first task is to go through your list of alternatives one last time to make sure that each falls under the rubric of Toxics Use Reduction.

The key question here is whether the change promises to reduce the use of toxics and/or the generation of byproducts at the source. Screen out any options which merely shift toxic byproducts from one waste stream to another, or which treat or recycle byproducts after they have already left the production unit. These may be worth implementing -- but they are not TUR.

You might also find that some options are so straightforward, inexpensive, effective and easy to implement that no further assessment is needed in order to approve them.

Technical Screening

The task here is to eliminate options which are not feasible from a technical point of view. If you have process engineers on your TUR staff, they should be able to help you identify these options.

Some options can be ruled out immediately because they simply cannot be achieved -- even given unlimited resources. Other options can be ruled out because they call for equipment which is not commercially available and cannot be developed in-house.

Financial Screening

The point of this screening is to eliminate options which call for capital outlays far beyond the means of your firm. This step should not require detailed financial analyses -- that will be done at a later stage. Provided that you have a rough idea of the costs and benefits of each proposal, you should already be in a position to identify and rule out those which are much too costly to merit further attention.

Technical Assessment

If an option requires commercially available machinery, you may want to assign a team member to look into the track record of the equipment and its vendor. Where possible, it usually pays to visit a site where the equipment is in use or to obtain the equipment for a trial run. If this is impossible, you may wish to contact users by phone to query them about their experience. It may also be wise to determine whether the vendor handles upkeep, provides technical assistance, ensures the availability of spare parts, and/or offers an adequate guarantee.

Make sure that each option is compatible with your production rates and work practices. Also, investigate any possible effects on defect rates, product appearance and product quality.

This is also the time to rule out options which might have adverse side-effects on other production machinery or processes. Make sure that each option is compatible with your production rates and work practices. Also, investigate any possible effects on defect rates, product appearance and product quality.

There are also a number of potential logistical problems which must be foreseen and addressed. For instance, be sure that you have or can install the appropriate utilities (electric, process water, cooling water, coolant fluid, steam, fuel) for any new equipment, and that you have enough space to house the equipment and store any required supplies. Similarly, if the change requires in-house laboratory testing or analysis, make sure that you have the facilities to handle the task.

When comparing various options, you may also wish to take into account the amount of production down-time each would cause.

Managerial Assessment

It is critical to assess the fit of each option with your firm's managerial goals. This sort of consideration can often be decisive in choosing and gaining approval for TUR changes.

If your firm has issued a TUR Policy Statement or if your team has set TUR goals, you should consider whether the proposed changes are consistent with the statement and/or goals. You may also wish to assess proposed TUR changes for their compatibility with quality, efficiency and safety goals, marketing plans, community relations concerns, and other related management aims and priorities

It is also important to weigh the compatibility of each proposed change with the work habits and talents of employees Some TUR production changes will require technical consultants or new personnel in order to be implemented successfully. Such personnel requirements should be taken into account when comparing TUR alternatives. Other changes in work practices are difficult to sustain If you are considering a change which requires significant changes in production worker practices, you may want to consider an employee training and/or incentive program to encourage worker cooperation in making the change permanent.

Often, TUR changes require sustained cooperation among different departments. If you are considering such a change, you should ask yourself whether the cooperation is possible, and whether it might be enhanced by opening new lines of communication among departments or by creating a new inter-departmental task force to monitor progress.

Finally, it is worth considering the effects that the change will have on environmental paperwork and compliance. Usually, this effect will be purely beneficial. However, in some cases a TUR change may require new environmental permits or give rise to new compliance difficulties. This possibility should be explored before a decision is made.

into two traditional accounting categories: *direct costs* and *indirect costs*. As the name implies, direct costs are those which can be assigned *directly* to a particular product or production unit. This category has traditionally included such costs as equipment purchase and installation, production down-time, labor and raw material purchases.

Indirect (or "overhead") costs are those which cannot be assigned directly to particular products or production units. This category has traditionally included such costs as maintenance, waste treatment and disposal, environmental reporting and permitting, shipping and receiving, training, engineering, business planning, quality assurance, workers' compensation insurance, energy, water, and fuel.

Intangible costs – such as worker sick days, community relations, corporate image and employee morale – have a real bottom-line impact yet do not lend themselves to precise measurement.

You should also consider the effect of proposed changes on two other categories of costs: *intangible costs* and *liability costs*.

Intangible costs are those which have a real bottom-line impact yet do not lend themselves to precise measurement. For instance, since employees respond favorably to clean, safe work environments, your TUR changes should help to improve employee morale. Better employee morale is an intangible benefit, as it usually helps to boost productivity and profits -- though it is virtually impossible to quantify this bottom-line effect. Other examples of intangible TUR benefits include reduced worker sick days, improved community relations and improved corporate image.

Liability, on the other hand, is not an actual cost but a potential one. It is the cost faced by those companies which are found liable for damaging the environment, or for harming public or worker health, due to accidental releases of toxic substances. Under federal Superfund legislation, companies can also be held liable for clean-up costs of disposal sites they have used.

Because it represents a financial risk and not a concrete cost, liability is difficult to quantify. However, since it is a cost capable of bankrupting an otherwise healthy business, it cannot be ignored by an adequate financial analysis.

In order to draw up a comprehensive list of the costs associated with your current production processes, you may wish to begin with the process flow diagram which you prepared during the Process Characterization and Analysis phase of your work (see Chapter 3.3). This will help to organize your thought by permitting you to consider in turn the costs associated with each distinct stage of the production process.

The process flow diagram already contains a full list of the raw materials which are fed into your production process. The purchase costs of these raw materials constitute your *direct materials costs*, while the wages and benefits of the production line workers who run the process are termed *direct labor costs*. At many firms, accountants will already have calculated these costs for each product or production process.

Unfortunately, the other costs you are interested in – that is, indirect costs – are not usually measured separately under traditional accounting practices. For instance, the labor costs associated with environmental recordkeeping, fines, permits, compliance monitoring and reporting are usually counted as overhead, yet these costs are often reduced significantly by successful TUR. The same might be said for the costs of treatment, disposal, workers' compensation insurance, worker safety training and protective equipment and water use.

A comprehensive list of the costs associated with a given production process should include all of the materials, labor and utilities which contribute in some way to keeping the process running. The sample list provided in Figure 5B should help to get you started.

It should be noted that in smaller firms, the indirect labor costs might be harder to list, as the same person might carry out several different tasks which are related to keeping the production unit in operation. For instance, the supervisor might handle quality assurance and environmental compliance. However these various labor costs should still be listed separately, as a reduction in any of these tasks will free up time for other productive activities, and thus should be counted as a savings.

This list also omits several potentially important cost considerations, including **productivity** and **byproduct sales**. If you are considering a TUR change which will alter the production rates of your equipment, then this change should be considered when calculating costs and benefits. Likewise, if the change under consideration would create or eliminate a saleable byproduct, then this revenue shift should be figured into your financial calculations.

If you are considering a TUR change which will alter the production rates of your equipment, then this change should be considered when calculating costs and benefits.

TURA NOTE: Under TURA, an acceptable Toxics Use Reduction Plan must analyze the economic impact of toxics use in each production unit. All direct and indirect material and labor costs must be considered, including (at least) the following cost categories:

(1) Purchase or manufacturing costs;
(2) Storage, accumulation, treatment, disposal and handling (of toxics materials and byproducts);
(3) Costs associated with compliance with federal, state or local laws and regulations (including fees, taxes, treatment, disposal, reporting, labelling, etc.);
(4) Worker health and safety (including protective gear, lost employee time, etc.);
(5) Insurance costs;
(6) Potential liability costs (need not be quantified);
(7) Lost community goodwill and sales revenue lost to non-toxic competitors (need not be quantified).

Using this data, companies are to quantify the total annual cost of each toxic used in each production unit, and the total cost per unit of product. See Appendix 1 for further details.

(b) Identifying Operating Costs Which May Change

Once you have generated a comprehensive list of the operating costs currently associated with the process targeted for change, the next task is to identify those costs which might or would be changed by the TUR proposal under consideration. In the language of financial accounting, the task is to single out all of the **differential costs**.

This step is not easy to reduce to a foolproof formula. However, you should be able to identify differential costs by combing through the comprehensive list of costs which you have just generated and applying your knowledge of your production processes and the TUR alternative. In the process, you should be able to identify a set of operating costs which will definitely change and others which are relatively likely to change.

FIGURE 5C: SAMPLE DIFFERENTIAL COST LIST

(Probable differential costs between the paper-clip manufacturing process in Figure 3C and the same process after the introduction of aqueous-based cleaning)

1. DIFFERENTIAL DIRECT MATERIAL COSTS:
   - a. Cleaner solution purchases (decrease)
   - b. Hydrochloric acid purchases (possible increase)
2. DIFFERENTIAL DIRECT LABOR COSTS:
   - a. Production line employee wages and benefits (possible change)
3. DIFFERENTIAL INDIRECT MATERIAL COSTS:
   - a. Disposal (decrease)
   - b. Treatment (possible increase)
   - c. Environmental taxes (TURA may fee decrease)
   - d. Maintenance (possible increase)
   - e. Insurance (possible workers' compensation decrease)
   - f. Office supplies (probable marginal decrease)
   - g. Process water (negligible increase due to make up cleaning solution)
4. DIFFERENTIAL INDIRECT LABOR COSTS:
   - a. Environmental (Possible decrease in time spent on Forms S and R)
   - b. Quality assurance inspectors (probable temporary increase)
   - c. Training personnel (possible decrease in time spent on safety training)
5. DIFFERENTIAL INTANGIBLE COSTS:
   - a. Worker sick days (possible decrease)
   - b. Community relations (possible improvement)
   - c. Corporate image (possible improvement)
6. DIFFERENTIAL LIABILITY COSTS:
   - a. Liability for worker health suits (decreased exposure)
   - b. Superfund liability (decreased exposure)
   - c. Toxic Tort Liability (decreased exposure)

benefits rate for the sort of work which would be added or eliminated. (hourly benefits rate = annual cost of benefits per worker/hours worked per year) The annual differential can then be figured by adding hourly wage and benefits, and multiplying the sum by the number of extra hours of work which would be caused by the TUR change. (Direct labor differential = (hourly wages + hourly benefits) x extra work hours)) If the TUR change would reduce labor hours, then the extra labor hours should be a negative number, and the resulting differential negative (i.e. a potential savings).

You should try to bring as many differential costs as possible within the scope of your quantitative analysis. Provided that your numbers are dependable, this will add to the credibility and usefulness of your overall financial analysis.

Where possible, you should try to bring other differential costs within the scope of your quantitative analysis. Provided that your numbers are dependable, this will add to the credibility and usefulness of your overall financial analysis.

There are a number of indirect material costs which can sometimes be quantified. For instance, by securing technical data on new equipment which would be installed under a TUR proposal, you might be able to calculate the annual cost differential for electricity, water, or other utilities. Similarly, if you know something about the reliability record of the equipment you are considering, then you might be able to gauge maintenance cost differentials.

There may also be indirect labor costs which can be brought within the scope of your quantitative analysis. For instance, if you can determine the amount of time spent by employees in filling out regulatory reports or applying for permits which your TUR proposal would render unnecessary, then you can include these indirect labor savings in your quantitative analysis. The same goes for time spent by laboratory personnel in testing and analysis or time spent by managers in fulfilling OSHA requirements for safety training, hazard communication and emergency planning. In each case, the appropriate mathematical formula is the same one used for direct labor costs.

To give an example, suppose that your TUR project would eliminate a particular hazardous waste which you now send to the landfill. Your conversations with environmental personnel reveal that (among other things) this would eliminate two hazardous waste shipments per month, and that each shipment requires two manifest reports which take an environmental engineer 1.5 hours each to complete -- hours which could otherwise be productively used. Suppose further that the wages and benefits of the environmental engineer total $30/hour. The indirect labor cost differential for manifest reports would then equal $2,160 per year ($30 per hour x 1.5 hours per manifest x 48 manifests per year)

You may also have quantifiable cost differentials arising from changes in byproduct sales revenues, depreciation allowances or production rates. If the TUR project in question would create or eliminate saleable byproducts, then the change in byproduct revenues must be counted as a differential cost. If the project calls for new equipment with a higher depreciation rate than old equipment, then you may wish to count the consequent tax savings as a differential cost. Finally, if your TUR proposal would alter production rates, then you will have to perform some rather delicate calculations to determine its net effect on your business -- as it might affect both your operating costs and your ongoing product sales revenues.

It is not easy to quantify those costs which traditionally fall within the categories of intangible costs or liability. In most cases, these costs will be weighed in the qualitative portion of the financial assessment. There have, however, been some efforts to put numbers to these costs. For instance, a 1988 study conducted for General Electric by ICF Technology, Inc. estimated the average liability cost of landfilled hazardous waste at $354 per ton. For landfills that have a history of leaks or are located near urban areas, wells, or groundwater, liability exposure was estimated to be higher by as much as 50%.

The estimation of potential liability has not become a widespread practice in part because the numbers tend to be unreliable, and in part because companies have feared that they would

The Qualitative Analysis: As noted above, you should strive to quantify as many costs as possible without diluting the reliability of your financial analysis. However, most TUR proposals will have some differential costs which cannot be quantified accurately.

These unquantifiable costs should be included in the qualitative portion of your financial analysis. This qualitative analysis may prove instrumental in choosing among otherwise equally attractive options or in justifying projects which stand at the edge of your firm's capital budgeting criteria.

The importance of these costs should not be underestimated simply because a number cannot be put to them. For instance, it is usually not possible to quantify the fines, lawsuits and criminal penalties which may accompany violations of environmental regulations, yet they can put a considerable dent in profits, and continued violations can lead to a forced plant shutdown. Similarly, it is difficult to provide a reliable figure for the future costs of Superfund clean-ups, toxic torts or worker compensation settlements -- yet these costs can cripple even the healthiest business.

Many businesses have recognized qualitative cost considerations by slackening their standard capital investment criteria for Toxics Use Reduction projects.

Many businesses have recognized qualitative cost considerations by slackening their standard capital investment criteria for pollution prevention projects. For instance, if standard improvements in work efficiency must have a three-year payback period, projects which reduce toxics use might only be required to pay for themselves in four or five years. This sort of lenience does not necessarily reflect a heightened environmental conscience -- it may also be in tune with the interests of corporate profits.

If your TUR analyses are to be submitted to higher management for review and approval, then your qualitative analysis is particularly important, as it provides a vehicle for pointing out the many unquantifiable bottom-line considerations which bode in favor of TUR. This portion of the financial analysis should mention a number of kinds of costs:

* **Costs which might *possibly* be changed by the project;**

* **Costs which will be changed, but by an unquantifiable amount;**

* **Liability exposure.**

The qualitative analysis usually takes the form of a brief written document which explains why the project is likely to lead to various possible costs and savings, and (where possible) estimates the likely magnitude of these costs/savings. It might also contain a discussion of the liability risk reduction which can be ushered in by successful TUR.

(d) Determining the Total Capital Cost of Your TUR Project

The next step in your financial analysis is to weigh all of the up-front costs associated with implementation of your TUR project. This is particularly important for projects which require substantial capital investments in new equipment, research and development, or plant expansion.

The capital costs of your TUR project are those one-time costs necessary to plan and implement the production process change. Figure 5D lists the capital costs which might be associated with a typical TUR project.

The basic drawback of a payback period calculation is that it ignores what is known as the **time value of money.** As a result, payback periods are useful for comparing alternate projects against each other, but they are not the most accurate means of determining whether funds should be spent on TUR in the first place.

even more attractive. This explains in part why many companies have lowered the financial hurdle which TUR projects must clear in order to be approved.

Focus: Other TUR Profitability Measures

If you have read this far, you should now understand how to calculate the payback period of a TUR proposal. However, if your project is to be submitted to upper management as a candidate capital investment, you may have to evaluate it with other, somewhat more complex measures of profitability, such as **Internal Rate of Return** or **Net Present Value.**

These more sophisticated profitability measures are introduced here in outline form only. A more complete guide to financial accounting for TUR projects can be obtained by contacting OTA at (617) 727-3260. OTA can also provide Massachusetts businesses with help in performing financial analyses of TUR projects.

The basic drawback of a payback period calculation is that it ignores what is **known as the time value of money.** As a result, payback periods are useful for comparing alternate projects against each other, but they are not the most accurate means of determining whether funds should be spent on TUR in the first place.

What, then, is meant by the "time value of money"? It is a term for the common-sense idea that a given quantity of money which will be received in the future is not worth as much as the same quantity of money in hand today. Before they can be compared to each other meaningfully, sums of money which will be spent or received at different points in time must be adjusted (or "discounted") to reflect the continually diminishing value of money.

As we have seen, capital investments in pollution prevention projects typically involve an up-front capital outflow (capital cost) and a gradual series of capital inflows (operating savings) over many years. Since these savings occur at different times in the future, a truly accurate financial analysis of the investment should discount them so that they can all be compared to the up-front capital cost.

These future inflows must be discounted at a rate which reflects the company's **cost of capital.** This figure varies from firm to firm—even within the same industry.

Net Present Value (NPV) and Internal Rate of Return (IRR) are two profitability measures which take into account the time value of money:

Net Present Value: Once the future cash inflows associated with a TUR project have been discounted, they can be added together to give the present value of the project's cash inflows. The project's total capital cost (the required up-front investment) can then be subtracted from this figure to derive the project's net present value (NPV). Generally, the project is considered acceptable if the NPV is greater than zero.

Internal Rate of Return: The internal rate of return (IRR) is the rate at which future inflows must be discounted in order to have a present value equal to the project's up-front capital costs. If capital costs and future inflows are known, this figure can be derived rather easily by a typical financial calculator. Most companies consider an after-tax IRR of 12% to 15% to be acceptable for low-risk investments. Your team may wish to find out what your company considers an acceptable IRR.

assessments of the project(s). In particular, you should recapitulate your findings about the project's effects on marketing plans and quality goals, its compatibility with employee skills and habits, and its role in the company's efforts to comply with current and future environmental regulations.

It may help to supplement the final report with information about health, safety, and environmental effects of all recommended changes. You might also wish to include a timeline for project implementation, with estimates of production down-time and projected construction schedules.

Your chances of getting funds for TUR projects will be greatly enhanced if you understand the political idiosyncrasies of the capital budgeting process at your firm.

Of course, success in the capital-budgeting process usually involves much more than just a convincing final report. Your chances of getting funds for TUR projects will be greatly enhanced if you understand the political idiosyncrasies of the capital budgeting process at your firm. For instance, it may help to enlist the support of key managers by educating them about the potential benefits of toxics use reduction. It may also be useful to solicit the active support of all department heads who would be affected by the change.

Even when a project promises to pay for itself rapidly, it may not be funded during a given round of capital budgeting allocations. This can happen for many reasons. For instance, your firm may have other priorities at the moment, or there may be a temporary shortage of funds. If a technically attractive and financially sound option is rejected, your team should be certain to resubmit it during the next capital budgeting period.

Chapter 6:
Implementing Projects and Tracking Progress

Chapter 6: Implementing Projects & Tracking Progress

This Chapter Addresses the Following Topics:	
6.1	Implementing TUR Changes.
6.2	Measuring TUR Progress.
6.3	Documenting Accomplishments and Sustaining Commitment.

6.0: Implementing Projects and Tracking Progress - An Overview

Your team has now evaluated, selected and – where necessary – secured approval for the implementation of one or more TUR projects. The next steps are to implement the change(s) in a way which ensures their sustainability, and then to measure and document your progress in achieving TUR reductions.

The implementation of a TUR project may involve worker retraining, process redesign, procurement of new equipment, installation work, and/or product research and development. These changes must be planned carefully, in order to coordinate the efforts of all affected departments and personnel.

The implementation process does not end when the new equipment and/or new work practices are in place. Successful implementation means making the change *workable* and *permanent*. Your TUR team can improve the odds of success by staying in touch with all affected workers and handling any difficulties which may arise.

One of the most critical elements of your team's follow-up work is to measure your TUR progress. Such measurements will help your team to document and reproduce successes, learn from failures, and gain the data needed to secure approval for future TUR projects.

Once your team has carried out its first TUR project, it is important not to lose steam. TUR is best pursued through continued incremental changes, each reflecting the proven technologies and capital resources available at a given time.

With each project, your TUR team should become more knowledgeable and more effective. By sustaining your commitment, your TUR team can help to build a company-wide awareness of TUR as a responsible and cost-effective approach to industrial toxics, while making concrete production-line changes with a positive impact on the environment.

6.1: Implementing TUR Changes

Some TUR changes require relatively little planning and can be implemented as soon as approval is secured. In general, changes in work procedures and processing parameters fall

TURA NOTE: Acceptable TURA plans must include an implementation schedule for all planned TUR changes, together with calculations of the expected reductions in toxics used and byproduct generation associated with each change. Biennial plan updates must explain any failures to meet past implementation schedules. See Appendix 1 for more information.

Measurements of TUR progress will help you to document your successes and failures, learn from your experiences, spot fresh opportunities for TUR, and gain the sort of results-oriented data which may help in obtaining approval for additional TUR projects.

6.2: Measuring TUR Progress

In order to develop a sustained and effective program, it is extremely important to measure your progress in toxics use reduction. Such measurements will help you to document your successes and failures, learn from your experiences, spot fresh opportunities for TUR, and gain the sort of results-oriented data which may help in obtaining approval for additional TUR projects.

TUR progress can be measured in a number of ways. Some measurement methods are relatively easy and require little data-gathering, yet they are imprecise. Other methods are more precise but require more time.

It is possible to measure your progress in loose, qualitative terms. For instance, you might confirm that use of certain toxics or production of certain toxic byproducts has been reduced significantly, without quantifying the precise degree of reduction. For some purposes, a rough estimate of reduction percentages might suffice.

The shortcoming of such a qualitative measurement technique is that it may not supply accurate enough data to fill out Form R's and Form S's, spot new opportunities for TUR, or convince upper management that your TUR efforts have met with success. If you wish to measure your progress with more precision, you should measure changes either in the quantity of toxics used or in the quantity of toxic byproducts generated.

Your choice of a measurement technique might hinge on the availability of data. If you have ready access to data on the quantity of toxic substances used in the processes you have modified, then you might wish to measure progress by tracking use reductions directly. On the other hand, it may be worth generating additional data to track reductions in toxic byproducts, as this is the measurement method mandated by the Toxics Use Reduction Act (TURA).

Whichever method you choose, you will need accurate before-TUR and after-TUR data, and you will have to adjust your measurements to account for the effects of extraneous factors such as changes in the rates at which various products are made.

This manual describes a method for measuring reductions in toxic byproducts. This data will not only help you to track TUR progress – it will also help you to understand the precise effects of your TUR changes, and to spot fresh opportunities for additional reductions in toxics use. Those firms subject to TURA planning requirements are *required* to use this method for reporting their TUR progress.

During the analytical phase of your TUR planning (see Chapter 3), you used basic materials accounting tools to quantify the magnitude of the toxic byproducts created by the processes you were investigating. This data will give you the baseline you need to measure your TUR progress. If you have not already quantified your byproducts, make sure to do

Focus: Identifying a Unit of Product

The semiconductor industry faces some thorny problems in identifying an appropriate unit of product. However, local manufacturers have found that with a bit of creative thinking, a workable solution can be found.

One local semiconductor manufacturer began by considering "microchips produced" as its unit of product. However, this proved unworkable for at least two reasons. First, not all chips which the firm produced were functional, yet a decrease in the number of non-functional chips should count as TUR progress. Second, some chips were far more complex than others, and the manufacture of these more complex, multi-layered chips required more processes, and hence more toxic substances, than simpler chips. However, since these complex chips typically do the work of a great many simpler chips, it made no sense to view them as a less efficient use of toxics.

Individual chips are cut from larger silicon wafers after the wafers have been masked with layers of oxides, etchants and silicon. Thus, the firm in question next considered "wafers produced" as a possible unit of product. However, the wafers produced by this firm varied in diameter from four inches to six inches, and they carried anywhere from 10 to 20 masking layers. Because of these variations in wafer size and complexity, there was no predictable correlation between the number of wafers produced and the volume of toxics used or released as byproducts.

These difficulties were solved by tracking "square inches of silicon produced," and multiplying this by a complexity factor related to the number of masking layers used. Company engineers found that the resulting unit of product correlated nicely with the amount of hydrofluoric acid and other toxics which were either used or created by the process.

Once you have identified an appropriate unit of product, you can use the data generated by the materials accounting you did in Chapter 3 to create a baseline for measuring TUR progress.

Gauging TUR Progress

Once you have identified an appropriate unit of product, you can use the data generated by the materials accounting you did in Chapter 3 to create a baseline for measuring TUR progress. Your materials accounting data should tell you how much toxic byproducts your pre-TUR process is creating during a given period of time. If you divide this amount by the total units of product created during the same period, then you will have the before-TUR byproduct measure against which your TUR achievements can be gauged.

The after-TUR figure is generated in much the same way. You will need to engage in a fresh analysis of your modified production process, drawing up process flow diagrams and chemical pathway analyses, identifying all points at which byproducts are released, and using materials accounting or mass balance measures to assess the magnitude of those byproducts. If you need to refresh your memory on how this is done, refer back to Chapter 3.4.

Once you have implemented your TUR change, you can gauge your progress by measuring the total amount of the toxic substance which is released as a byproduct of the altered process over a given period of time, and dividing that figure by the number of units of product created over the same time period. This will give you your post-TUR byproducts per unit of product.

byproducts without actually reducing toxics use. As long as this sort of change falls under one of the six categories of TUR techniques, it counts as TUR under the law. It may also be very laudable – particularly if the toxic breaks down into benign components.

TUR should not be a one-shot affair. Quite the opposite: your first TUR projects should provide the sort of learning experience needed to make your team more proficient at identifying, planning and carrying out TUR changes.

TURA NOTE: Measurement of progress is required under TURA's annual reporting requirements (Form S). These reports must identify all production units at the facility, specify the unit of product for each production unit, measure the byproduct reductions achieved for each toxic substance used in each production unit, and identify the kinds of TUR that have resulted in byproduct reductions of 5% or more. These reductions are expressed in terms of a **Byproduct Reduction Index**, which represents the percentage reduction achieved in byproducts-per-unit-product. These reduction percentages, in turn, are measured in terms of annual byproduct magnitudes, and indexed against byproduct magnitudes from a base year specified on the form.

Form S also calls for the annual reporting of an **Emissions Reduction Index** for each toxic substance in each production unit. This latter figure represents the percentage reduction achieved in toxic emissions which are attributable to the production unit.

The key to accurate measurement of progress under TURA lies in the selection of appropriate production units, products and units of product. The law permits a wide degree of latitude in applying these categories to your facility. Each firm should seek to designate production units whose products can be counted in a way which permits meaningful measurement of TUR progress. That is, products must be divisible into units of product with relatively uniform toxic byproducts or relatively uniform toxics use.

For instance, the law permits firms to group similar products together as families of products, which can be treated as a single product. These groupings will usually hinder the measurement of TUR progress unless each member of the family is produced with the same technology and can be counted in some way that yields a similar per-unit rate of toxic byproducts or toxics use.

See Appendix 1 for more information about measurement of progress under TURA.

6.3: Documenting TUR Accomplishments and Sustaining Commitment

From the beginning, this manual has presented toxics use reduction as a new way of thinking about your production processes – one which should inform *all* aspects of your production planning on an *ongoing* basis. The manual recommends the creation of a TUR team to institutionalize this new way of thinking by spreading awareness throughout the firm, analyzing toxics use in production processes, identifying and evaluating TUR options and overseeing the implementation of TUR changes.

If TUR is to take root and prove genuinely successful in your plant, it is critical that your planning process from the beginning, in order to insure that TUR measures are built into the final result.

Your team can also enhance its effectiveness by staying abreast of new TUR technologies and production techniques which might help to reduce your firm's reliance on toxics. To this end, you should trade ideas with other firms pursuing TUR, send representatives to trade fairs or expositions focusing on environmental technologies, and stay in contact with OTA and the Toxics Use Reduction Institute at the University of Massachusetts at Lowell.

Remember that TUR alternatives take shape against the backdrop of pending regulations, shifting costs of raw materials and disposal, and changing public concerns and customer demands. It is important to be aware of any changes in this environment which might help you to identify new TUR opportunities or to make a case for TUR changes which might previously have been unattractive.

With the right combination of enthusiasm, persistence and sustained commitment, your team can slowly build corporate-wide awareness of TUR as an environmentally responsible approach to industrial toxics which is sensitive to the bottom-line concerns of business.

In these ways, TUR is closely related to the much-discussed notion of Total Quality Management. Like Total Quality Management, TUR requires the active and sustained commitment of a wide range of personnel: from top management, to purchasers, to research and development personnel, to production line workers. Both sorts of programs also call for continuous incremental improvements, each of which moves your firm closer to the ultimate goal of best possible quality or of least possible toxics use and zero toxic discharge. And both require continuous reconsideration of new techniques, technologies and cost factors which might make feasible the further improvements which yesterday could not be attained.

With the right combination of enthusiasm, persistence and sustained commitment, your team can slowly build corporate-wide awareness of TUR as an environmentally responsible approach to industrial toxics which is sensitive to the bottom-line concerns of business. In the process, you can help to make concrete production-line changes which will have a positive impact on worker health and safety, public health, and on the natural environment we all share.

Appendix 1: TURA Requirements and This Manual

Appendix 1: TURA Requirements and This Manual

This Appendix Addresses the Following Topics:

A1.1	**The TURA Basics.**
A1.2	**TURA Reporting Requirements.**
A1.3	**TURA Planning Requirements.**
A1.4	**Seeking Further Information about TURA.**

A1.0: TURA Requirements and This Manual -- An Overview

As noted in the introduction, TUR is not only a new business practice and a new mindset for thinking about environmental protection – it is also a new approach to environmental legislation. To date, more than one dozen states have passed legislation requiring businesses to carry out TUR or other closely related pollution prevention initiatives. In July of 1989, the Massachusetts legislature unanimously passed the Toxics Use Reduction Act (TURA), the first and one of the most ambitious of these state pollution prevention bills.

TURA, which was developed in close cooperation with industry leaders, requires large-quantity users of toxic materials to report on their use of toxic substances, and to undergo a planning process aimed at identifying and evaluating TUR options. TURA sets "a statewide goal of reducing toxic waste generated by 50% by the year 1997 using toxics use reduction as the preferred means of meeting this goal." Other goals of TURA include: establishing TUR as the preferred means for regulatory compliance, promoting the competitiveness of Massachusetts industry, and coordinating state environmental programs.

This general-purpose manual is designed to help launch successful TUR programs at all Massachusetts institutions which use toxics – both those which are required to do TUR planning by the state's Toxics Use Reduction Act (TURA), and those small-quantity toxics users not covered by the law. The aim of this manual, then, is not principally to help businesses meet the letter of the TURA planning requirements, but to promote TUR as a new way of thinking about manufacturing processes and their impact on corporate finances and the environment. The emphasis is on helping businesses to create and sustain in-plant TUR programs which identify and act on TUR opportunities.

However, while this manual is not focused specifically on compliance with TURA, it should prove quite useful to any firm seeking to understand and meet the requirements of the law. OTA's experience indicates that forming a TUR team and launching the sort of TUR program described in this manual is the most effective way to accomplish the kind of toxics use reduction encouraged by the law. This remains true whether or not your firm plans to retain an environmental consultant to help you comply with TURA.

recycling only counts as TUR if it is integral to the production unit in which the toxic substance is used. The reason for this requirement is that off-site or out-of-process recycling requires handling and transportation of toxics -- either within a factory or between two plants, via public highways. This handling and transportation can pose a risk to the environment, as well as to public and worker health. Thus, while recycling toxic substances is usually better for the environment than simply discarding them, it is not the sort of optimum solution which eliminates the threat posed by toxics by cutting them off at the source.

It is worth mentioning a few other kinds of production changes which do not count as Toxics Use Reduction. For instance, on-premises treatment or incineration of toxics is not a form of TUR. Likewise, any production change which shifts risks from one medium (i.e. air, water, landfill) to another does not count as TUR.

By July 1, 1994, each Large Quantity Toxics User must develop and certify a Toxics Use Reduction plan with specific two-year and five-year reduction goals and a detailed implementation schedule.

Who Is Subject to TURA?

TURA planning and reporting requirements apply to firms which meet all three of the following criteria:

- **Process or manufacture at least 25,000 pounds or otherwise use at least 10,000 pounds** of substances regulated under Title III of the federal Superfund Amendment and Reauthorization Act (SARA). From 1991 to 1993, the act was expanded gradually to include all substances regulated under the federal Comprehensive Environmental Response and Compensation Liability Act (CERCLA). Additional chemicals may be added to or deleted from the list at the rate of no more than 10 per year at the discretion of the TUR Council.

- **Employ 10 or more** full-time employees (or the equivalent, where 1 full-time employee = 2,000 work hours per year.)

- **Fall within Standard Industrial Classification (SIC) codes** 10-14 (mining); 20-39 (manufacturing); 40, 44-49 (transportation, communications, gas, electric, and sanitary services); 50,51 (wholesale trade); and 72,73,75,76 (certain services).

Companies which meet *all three* of these criteria are categorized by the law as **Large Quantity Toxics Users (LQTUs)**. These firms are required by TURA MGL Chap. 21I) to file annual reports which detail their use of listed substances and document their ongoing efforts to reduce or eliminate their dependence on these substances. By July 1, 1994, each of these businesses must develop and certify a Toxics Use Reduction plan with specific two-year and five-year reduction goals and a detailed implementation schedule. These plans must be updated every two years. Section A1.3 of this Appendix explains this planning process in some detail. The Addendum contains the TURA Planning Regulations (310 CMR 50.00).

All Massachusetts toxics users which do not meet the above three criteria are categorized as **Small Quantity Toxics Users (SQTUs)**. After July 1, 1995, certain SQTUs which fall into designated "priority user segments" may also be subject to TURA reporting and planning requirements.

The implementation of TURA is funded by an annual fee levied on all LQTUs, based upon the number of people they employ and the number of chemicals they use at above-threshold levels. This fee covers DEP's regulatory and enforcement costs associated with TURA, Under the law, a product is defined as "a product, family of products, an intermediate product, a family of intermediate products, or a desired result or a family of results." It is worth giving a good deal of thought to the appropriate specification of products and production units, as these groupings will provide the framework for your TURA planning and your annual progress reports. A judicious division of your plant can help make your TURA planning efforts more effective and your annual measurements of progress more meaningful.

Essentially, there are two ways in which firms can gain flexibility in dividing their plant into production units. The first is by deciding whether to consider related products singly, or to group them together into a **family of products**. By considering each product singly, a firm can divide its plant into a large number of distinct production units. On the other hand, by grouping products into families, the number of production units can be minimized.

A judicious division of your plant into production units can help make your TURA planning efforts more effective and your annual measurements of progress more meaningful.

Firms can also gain flexibility in designating production units by counting **desired results** and **intermediate products** among their products. These categories are broad enough to include the outputs of many preliminary manufacturing stages. Thus, by specifying production units in terms of intermediate products and desired results, firms can achieve a more fine-toothed analytical division of their processes. Alternatively, they can reduce the number of production units by considering only final products and results.

From the point of view of paperwork simplification, it may appear attractive to ignore intermediate products and group finished products into a small number of large families, thus minimizing the number of production units on which you must report each year. However, broadly defined production units which encompass several different toxic chemicals and technologies are likely to confuse your efforts to analyze processes, pinpoint wastes and generate TUR alternatives. More importantly, broad production units are likely to make it impossible to measure TUR progress in any meaningful way.

In dividing your plant into production units, it is especially critical to designate production units for which relatively constant correlations exist between the volume of toxics used or generated as byproduct, and the amount of product produced. As was explained in Chapter 6, this is the key to meaningful measurement of TUR progress. Of course, the constancy of this correlation will depend in part upon how you decide to *count* your product – that is, on what **unit of product** you select. However, if you draw your production units too broadly, including within them products which are made through disparate production technologies, then there may be no way of counting products which will render a relatively constant correlation between toxics use or toxic byproduct generation, and units of product produced.

In general, you can group products together in one family of products if they do not differ significantly in the technologies used to produce them, the amount of toxic chemical used in producing them, and the amount of toxic byproducts generated while producing them. One way that progress is measured under TURA is by tracking reductions in toxic byproducts, so it is especially critical that you group together only those products which produce particular toxic byproducts at similar rates.

The final task in the division of your plant into production units is to specify a **unit of product** for each production unit. This must be done because your TUR progress cannot be measured meaningfully through raw measurements of toxics use or byproduct generation. Such measurements can shift due to factors having nothing to do with TUR – such as changes in production rates or in the average size of products. In order to render your byproduct data useful, you must relate it to the total number of units of product produced. For TURA reporting purposes, this is done by keeping tabs of *toxic byproducts per unit of product*.

The key here is selecting a unit of product which produces a constant per-unit magnitude of toxic byproducts. Such a unit of product may be expressed in terms of pieces produced, production process; that is, you may have to draw up process flow diagrams and conduct chemical pathway analyses in order to identify all points at which byproducts are released. Then, you will be in a position to use materials accounting to measure the magnitude of those byproducts. Provided that you have information about treatment efficiencies, you can use these byproduct magnitudes to gauge your emissions magnitudes. (If you need to refresh your memory on how these steps are done, refer back to Chapter 3.)

Once you have calculated your annual byproduct and emission magnitudes, you can divide them by the total units of product produced during the reporting year to gauge your byproducts per unit of product, and your emissions per unit of product. You now have the information needed to fill out your Form S.

One of the most important steps your firm can take to insure long-term TUR progress is to supplement your current record-keeping so that you have complete and accurate data on toxics use, and on byproduct and emissions generation.

The following formula will yield your **Byproduct Reduction Index** (where A = Base Year Byproducts/Unit Product; and B = Reporting Year Byproducts Per Unit Product):

$$\textbf{Byproduct Reduction Index} = 100 \times \frac{A - B}{A}$$

The emissions reduction index can be measured with precisely the same formula (where A = Base Year Emissions/Unit Product; and B = Reporting Year Emissions Per Unit Product).

When measuring reporting year byproducts, keep an eye out for byproducts or emissions arising from maintenance or cleaning operations which are not performed routinely. If your reporting-year data reflects waste from these operations and your base-year data does not, this may cause you to understate your progress. Such anomalies can be noted in section 1.4 of the Form S

TURA does not require firms to install new monitoring equipment to gather the data required for TURA reporting. Instead, firms are asked to use the best information they have on hand. However, one of the most important steps your firm can take to insure long-term TUR progress is to supplement your current record-keeping so that you have complete and accurate data on toxics use, and on byproduct and emissions generation. Whatever your record-keeping techniques, TURA requires all firms to maintain on-site records of the data used to perform the calculations required by the Form S report.

Trade Secrets

Any information included on the Form S reports is available to the public unless the firm requests trade secret status for that specific piece of information. Then, it will be kept confidential unless DEP determines that the information is not a trade secret.

There is a space for requesting trade secret status on the Form S Cover Sheet. In order to qualify as a trade secret, information must meet specific criteria spelled out in Department of Environmental Protection regulations (310CMR 3.30).

In general, the forms should reveal nothing of interest to competitors, as they include neither the quantity of product or byproducts or emissions produced. They contain only percentage changes in byproducts and emissions per unit of product, and these numbers cannot in general be used by competitors to determine how much of any given chemical is being used by or released from your plant.

change in toxics use, and percentage change in byproduct generation. (See Chapter 2.3 on goal-setting and Chapter 3 on materials accounting)

(b) Production Unit Information

For each production unit, the plan must include a process flow diagram which provides a visual representation of the movement of toxics within the production unit -- both those which flow into the process as raw materials and those which exit the process as byproducts, emissions or products.

(i) Process Flow Diagrams: For each production unit, the plan must include a process flow diagram which provides a visual representation of the movement of toxics within the production unit -- both those which flow into the process as raw materials and those which exit the process as byproducts, emissions or products. The diagram must represent each step in the manufacturing process, including waste treatment activities and recycling activities that are not integral to the production unit. The number assigned to the production unit for Form S reporting purposes must appear on the process flow diagram. (See Chapter 3.3 on Process Flow Diagrams.)

(ii) Current and Projected Toxics Use and Byproduct Generation: The plan must include the following materials accounting figures for each production unit: (i) the total amount, and the amount per unit of product, of each covered toxic manufactured, processed or otherwise used; (ii) the total amount, and the amount per unit of product, of each covered toxic generated as a byproduct; (iii) the total amount, and the amount per unit of product, of each covered toxic released or transferred off-site as an emission. (See Chapter 3.1 on data-gathering and Chapter 3.4 on materials accounting.)

(iii) Unit of Product: The unit of product which has been chosen for each production unit must be identified in the plan. (See Chapter 6.2 and section A1.2 of this Appendix.)

(iv) Purpose Served by Toxic: The plan must contain a statement explaining the purpose that each toxic serves in each unit of product.

(v) Byproduct Measures: For each byproduct identified on the process flow diagram, the plan must include the amount treated on-site, treated off-site, recycled on-site, recycled off-site, disposed of on-site, disposed of off-site, or released. (See Chapter 3.3 and 3.4)

(vi) Emission Measures: For each emission identified on the process flow diagram, the plan must include, for each environmental medium, the amount released to the environment, transferred off-site, treated off-site, recycled off-site, or disposed of on-site or off-site. (See Chapter 6.2)

(vii) Cost of Toxics Use: The plan must include the cost of the use of each toxic, as calculated in the financial analysis portion of the plan. (See below, A1.3, section 'c')

(viii) Byproduct Reduction Goals: The plan must include two-year and five-year goals for the Byproduct Reduction Index, reflecting the expected impact of the TUR techniques chosen for implementation. (See Chapter 2.3)

(c) Financial Analysis of Toxics Use

For each toxic used in each production unit, the plan must include the total cost per year and capital budgeting procedures.

*An examination of the relationship between the option and other applicable laws and regulations, including but not limited to whether implementation of the option will violate any other laws or regulations.

(iv) **Evaluations Which Need Not Be Completed:** Toxics Users need not complete evaluations of options which are clearly technically infeasible, clearly financially infeasible, or which are not likely to result in reductions in toxics use or byproduct generation per unit of product.

The plan must describe each option chosen for implementation, detail the costs and savings associated with it, and list the reductions in toxics use and byproduct generation which are expected to result from the option.

(v) **Options Not Chosen for Implementation:** The plan must describe each listed option which will not be implemented, and explain why the option was not chosen for implementation.

(vi) **Options Chosen for Implementation:** The plan must describe each option chosen for implementation, detail the costs and savings associated with it, and list the reductions in toxics use and byproduct generation which are expected to result from the option. (From above-described Options Evaluation) The plan must also include an implementation schedule. (See Chapter 6.1.)

(vii) **Incomplete Evaluations:** If the evaluation of a particular option cannot be completed in time to be submitted with the plan, the plan must include a description of the option, an explanation as to why the evaluation remains incomplete, and a schedule of steps which will be taken to complete the evaluation.

(e) The Plan Summary

TURA plans are not submitted to DEP but remain instead on the plant premises, subject to DEP inspection. However, a plan summary must be submitted to DEP by July 1 of the year in which the plan is due. The summary must include:

(i) **A copy of the plan certification statement.**

(ii) **Expected Facility-wide Changes in Toxics Use and Byproduct Generation:** Two-year and five-year projections must be made for: expected change in pounds used, expected change in pounds of byproduct generated, expected percentage change in use, and expected percentage change in byproducts. (See Chapter 2.3 on goal-setting and Chapter 6.2 on measuring TUR progress)

(iii) **Byproduct Reduction Goals:** Two-year and five-year goals for the Byproduct Reduction Index. These goals must reflect the expected impact of the TUR techniques which have been chosen for implementation. (See Chapter 2.3)

(iv) **TUR Matrices:** For each production unit listed on the Form S, the plan must include a matrix of the sort which accompanies the Form S report. The matrix should indicate which of the six kinds of TUR (See Chapter 4.2.) will be implemented over the next five years,

Appendix 2: Glossary of TUR Terms and Acronyms

Appendix 2: Glossary of TUR Terms and Acronyms

A

Anodizing: A process that coats aluminum with a hard, corrosion-resistant oxide coating.

B

Byproduct: Under TURA, "All nonproduct outputs of toxic or hazardous substances generated by a production unit, prior to handling, transfer, treatment or release." If the "byproduct" is reused as is without processing or treatment, it may be regarded as product.

Byproduct Reduction Index: A calculation used for TURA reporting purposes which represents the percentage reduction achieved, over a specified baseline year, in byproducts per unit of product. See Appendix A1.2 and Chapter 6.2.

C

Capital Costs: One-time costs of planning and implementing a production change. See Figure 5D

CERCLA: Comprehensive Environmental Response and Compensation Liability Act (federal) All toxics listed under CERCLA will be included in TURA by the end of 1993.

Chemical Inputs Database: A database which lists the chemicals in use in a plant and specifies the amount used, the cost of the substance, the waste streams in which it appears, the regulations to which it is subject, and the processes or operations in which it is used. See Chapter 3.1.

Chemical Outputs Database: A database that lists each chemical leaving a plant, and specifies the amount released, the treatment and disposal costs, the waste streams in which it appears, the regulations to which it is subject, and the processes in which it is used. See Chapter 3.1

Chemical Pathway Analysis: A diagram which graphically depicts the pathway of a toxic chemical through a production unit, and locates all points at which portions of the substance are released as byproducts. See Figure 3D.

Cost Differential: The annual change in operating costs realized by a TUR project or any other capital project

D

DEP: Department of Environmental Protection (Commonwealth of Massachusetts)

Differential Costs: Operating costs which would be changed by a TUR project or any other capital project. See Figure 5C.

Direct Costs: Operating costs which can be assigned directly to a particular product or production unit. See Figure 5B.

or less toxic substance." See Figure 4C.

Intangible Costs: Operating costs which have a real bottom-line impact yet which do not lend themselves to precise measurement. See Figure 5B.

Intermediate Product: Under TURA, "(a) in chemical manufacturing, any chemical substance that is consumed, in whole or in part, in chemical reactions used for the intentional manufacture of another chemical substance or mixture, or that is intentionally present for the purpose of altering the rate of chemical reactions. . . ; (b) in any other setting, any manufactured substance that is consumed, in whole or in part, in a chemical or physical process for the intentional manufacture of another product, becomes a component part of another product, or that is intentionally present for the purpose of aiding the manufacture of another product."

L

Liability: In the context of TUR, liability is the potential cost which may arise from being found liable for damaging the environment or for harming public or worker health.

LQTU: Large Quantity Toxics User. Under TURA, this category includes "any toxics user who manufactures, processes, or otherwise uses any toxic or hazardous substance in an amount the same as or greater than the applicable threshold amount in a calendar year at the facility." See Chapter 1.3

M

MSDS: Material Safety Data Sheet (required by OSHA Communication Standards).

Materials Accounting: Any analytical technique aimed at identifying and quantifying the materials which enter and exit a given production process or production facility. See Chapter 3.4.

Media/Medium: The three environmental media are air, water, and land.

N

NPDES: National Pollution Discharge Elimination System (NPDES) discharge permits are issued by the federal EPA under the federal Water Pollution Control Act.

O

OSHA: Occupational Safety and Health Administration (federal)

OTA: Office of Technical Assistance for Toxics Use Reduction, the nonregulatory state agency which authored this manual, was established by TURA to provide confidential technical TUR assistance at no charge to Massachusetts toxics users. OTA can be reached during business hours at (617) 727-3260. See Chapter 1.4.

SQTU: Small Quantity Toxics Users. Under TURA, all toxics users which are not classified as LQTUs (See LQTU definition above).

Superfund: The federal program authorized by CERCLA and SARA which carries out EPA's solid waste emergency response and long-term remediation activities.

T

Toxics/Toxic Substance: Under TURA, any chemical on the toxic chemical list under EPCRA section 313. By 1993, all chemicals regulated under CERCLA sections 101(14) and 102 will also be considered toxic under TURA.

TUR: Toxics Use Reduction. Under TURA, "in-plant changes in production processes or raw materials that reduce, avoid or eliminate the use of toxic or hazardous substances or generation of hazardous byproducts per unit of product, so as to reduce risks to the health of workers, consumers, or the environment, without shifting risks between workers, consumers, or parts of the environment." TUR can be achieved through six techniques: product reformulation, process redesign, process modernization, input substitution, reuse/recycling, and improved operation and maintenance. See Chapter 1.1.

TURA: Massachusetts Toxics Use Reduction Act (MGL Chap. 211, Regulations: 310 CMR 50.00). See Chapter 1.3 and Appendix 1.

TURI: Toxics Use Reduction Institute (state). TURI was established by TURA to research and publicize TUR opportunities, offer courses and seminars on TUR, certify TUR Planners, and carry out other related activities. The Institute, which is located at the University of Massachusetts at Lowell, can be reached at (508) 934-3275.

U

Unit of Product: Under TURA regulations (310CMR 50.10), "A measure that reflects the level of production or activity associated with the use of the toxic or the generation of the toxic as byproduct." See Chapter 6.2 and Appendix A1.2.

W

Walkthrough: An on-site inspection of production processes aimed at solidifying understanding of production processes and launching the search for appropriate TUR proposals. See Chapter 3.5

Appendix 3:
Bibliography of TUR Resources

Appendix 3: Bibliography of TUR Resources

Note: The following is a partial list of resources and publications on Toxics Use Reduction. Inclusion of any information which features particular products or proprietary technologies does not represent an endorsement of those products or technologies by the Commonwealth of Massachusetts, but simply an indication of their availability.

All of the following materials are available at the OTA library. Some of the materials can also be ordered from other sources, and where possible we have listed these sources. If you are interested in perusing or obtaining a copy of these materials, contact OTA at (617) 727-3260.

A. General Information on Toxics Use Reduction

1. The U.S. Pollution Prevention Information Clearinghouse (PPIC)

The U.S. Environmental Protection Agency maintains a free telephone service to handle inquiries about pollution prevention, and to assist in document searches. The PPIC has a library of more than 400 case studies of successful pollution prevention projects in a wide variety of industries. Many of these case studies fall within the category of Toxics Use Reduction. The EPA library also includes more than 600 holdings on federal, state and local pollution prevention projects, industry programs and waste minimization assessments. The PPIC can be reached by calling either the RCRA Superfund Hotline at (800) 424-9346 or the Small Business Ombudsman Hotline at (800) 368-5888. Technical questions can be addressed to experts at the PPIC Technical Assistance Hotline at (703) 821-4800

2. EPA Waste Minimization Opportunity Assessment Manual, 92 pp. Available from:

Hazardous Waste Engineering Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

3. Benefitting from Toxic Substance and Hazardous Waste Reduction: A Planning Guide for Oregon Businesses, 44 pp Available from:

Oregon Department of Environmental Quality
811 Southwest 6th St
Portland, Oregon, 97204
(503) 229-5913

Abstract: A planning manual for waste reduction, with worksheets which may prove useful to some Massachusetts businesses

4. Minnesota Guide to Pollution Prevention Planning, 108 pp. Available from:

The Minnesota Technical Assistance Program
Box 197 Mayo Building, 420 Delaware St.
University of Minnesota
Minneapolis, MN 55455
(612) 625-4949

Abstract: A planning manual for pollution prevention which is similar to this manual in scope and intent.

Abstract: A comprehensive guide -- complete with worksheets and software program -- to calculating the true costs of waste management alternatives and to identifying cost-effective waste minimization strategies.

5. **"Methods Used to Analyze Waste Control Options,"** 11 pp., by Douglas W. Cooper
Abstract: A look at cost/benefit analyses and risk assessments of hazardous waste management options under conditions of uncertainty.

6. **"Hazardous Waste Reduction -- Measurement of Progress,"** 15 pp., by Michael R. Overcash. Available from:

Michael R. Overcash
Department of Chemical Engineering
North Carolina State University, Raleigh, NC 27695-7905

Abstract: A new economic-based method for measuring waste reduction progress

7. **"Motivating Industry Toward Waste Minimization and Clean Technology,"** 11 pp., by Richard W. MacLean. Available from:

Richard E. MacLean
Corporate Environmental Programs
General Electric Company
3135 Easton Turnpike
Fairfield, CT 06431

D. Alternative Processes and Technologies: Metal Finishing

1. **"Closed-Looped Metal Finishing Processes,"** 11 pp., by Timothy Greiner, OTA

2. **"Waste Reduction in the Metal Finishing and Metal Plating Industries: Drag-out and Rinse Technologies,"** 1 p., Massachusetts OTA Brochure.

3. **"Waste Reduction in the Metal Finishing and Metal Plating Industries: Recovery Technologies,"** 1 p., Massachusetts OTA Brochure.

4. **"Wastewater Treatment and Recovery System at the Robbins Company,"** 2 pp., OTA Case Study.

5. **"Zinc Discharge at the Lowell Corporation,"** 2 pp., OTA Case Study.

6. **"Taunton Silversmiths Limited,"** 2 pp., OTA Case Study.

7. **Howard H. Sweet and Son, Inc.,"** 2 pp., OTA Case Study.

8. **"Source Reduction Recommendations for Precious Metal Platers,"** 20 pp., prepared by the Massachusetts OTA.

9. Case Studies from the Minnesota Technical Assistance Program and the Hazardous Waste Reduction Program of Oregon: Metal Finishing, 40 pp. Available from:

The Pollution Prevention Information Clearinghouse
(800) 424-9346

26. Waste Audit Study: Metal Finishing Industry, by the California Dept. of Health Services. Available from:

Department of Health Services
Toxic Substances Control Division
Alternative Technology Section
714/744 P Street
P.O. Box 942732
Sacramento, CA 94234-7320

27. **"20 Ways to Cut Water Usage in Plating Shops,"** 7 pp., by Ted Mooney. Available from:

Finishing Technology
Ted Mooney
14 Fiddler's Elbow
Kinnelson, NJ 07405
(201) 838-1346

28. **"Removal of Metal Cations from Chromium Plating Solution,"** 17 pp., by George C. Cushnie, Jr. of CAI Engineering, and Wayne Anderson of Harper and Thiel Inc.

29. **"Closed-Loop Processing of Chromic Acid Solutions,"** 10 pp., by Daniel J. Vaughan, William E. Schmidt and Beverly V. Schmidt of the Ionsep Corporation.

30. **"Rinse/Reclaim – Pollution Prevention for Metal Finishers,"** 3 pp., by Joseph J. Werbicki, Mirro-Brite Corporation, Pawtucket, RI.

31. **"Purification and Restoration of Chromic Acid Plating Solutions,"** 4 pp., Ionsep Corporate Brochure

32. **"Good Operating Practices in Electroplating: Rinse Water and Waste Reduction,"** 10 pp., by Peter A. Gallerani, president of Integrated Technologies, Inc.

33. **"Continuous Purification of Trivalent Chromium Plating Baths,"** 8 pp., by Joseph M. Ragosta, PhD and Dennis Darnall, PhD of Bio-Recovery Systems and Vincent C. Opaskar of Engelhard Corporation

34. **"PMF Nickel Recovery Project,"** 5 pp., by Jeff Collins and Christopher Gervascio of PMF Inc.

E. Alternative Processes and Technologies: Solvents

1. **"L. G. Balfour Company, Inc.,"** 2 pp., OTA Case Study.

2. **"Waste Management Opportunities: Solvents and Waste Oils,"** 1 p., OTA Brochure.

3. Case Studies from the Pollution Prevention Information Clearinghouse: Solvent Recovery, 31 pp. Call (800) 424-9346

4. **"Waste Minimization in Metal Parts Cleaning,"** EPA Document #530 SW-089049. Call (800) 424-9346.

5. **"Alternate Control Technology Document – Halogenated Solvent Cleaners,"** EPA Publication #450/3-89-030. Call (800) 424-9346.

6. Guidelines for Waste Reduction and Recycling: Solvents, 44 pp. A publication of the Oregon Hazardous Waste Reduction Program. Call (800) 424-9346.

2. **"Pulp and Paper,"** 17 pp.; and "Fly Ash," 5 pp., from Profits from Pollution Prevention. Available from:

The Pollution Probe Foundation
12 Madison Avenue
Toronto, Ontario
Canada M5R 2S1

3. **"Pollution Prevention Techniques for the Wood Preserving Industry,"** N.C. Pollution Prevention Program. Available from:

Pollution Prevention Program
The N.C. Dept. of Natural Resources and Community Development
P.O. Box 27687
Raleigh, NC 27611-7687
(919) 733-7015

4. **"Volatile Component Recovery from Sulfite Evaporator Condenser,"** by W. A. Sherman of the U.S. EPA. Call (800) 424-9346.

5. **"Process Spill Monitoring, Control and Recovery in the Pulp and Paper Industry,"** by G.W. Grove, J.J. McKeown, and A.J. Carlson of the U.S. EPA. Call (800) 424-9346.

6. **"Closed Water Loop in NSSC Corrugating Medium Manufacture,"** by G.O. Walraven, et al. of the U.S. EPA. Call(800) 424-9346

7. **"Advanced Filtration of Pulp Mill Wastes,"** by U.S. EPA. Call (800) 424-9346.

8. **"Toxicity Reduction Through Chemical and Biological Modification of Spent Pulp Bleaching Liquors,"** by U.S. EPA. Call (800) 424-9346.

9. **"A Novel Low-Pollution Approach for the Manufacture of Bleached Hardwood Pulp,"** 16 pp., by Alfred Wong and Jan Tichy of Arbokem Inc., Vancouver, Canada.

10. **"Practical Steps Leading Toward the Effluent-Free Mill,"** 6 pp., by B. Coetzee and C.J. Daviesof SAPPI Ltd., and F.E. Mera and L.K. Swift of Cas. T. Main, Inc., from "TAPPI Journal," April, 1985, pp. 92-7

11. **"Great Lakes Mill Cuts Effluent Loard With a Pressure Diffusion Washer,"** by J.C.W. Evans, from Pulp and Paper, vol. 59, no. 4, 1985, p. 100. Note: Not Available at OTA Library.

12. **"Recycle Approaches for Paper and Pulp Mills,"** 3 pp., by J.C. Wyvill and J.C. Adams, from Waterworld News, vol. : no. 5, September/October 1985, pp. 18-20. Note: Not Available at OTA Library.

13. **"Substituting Chlorine Dioxide for Elemental Chlorine Makes the Bleach Plant Effluent Less Toxic,"** by P. Axegard, from TAPPI Journal, vol. 69, no. 10, 1986, p. 54. Note: Not Available at OTA Library.

H. Alternative Processes and Technologies: Other Industries

1. **"Success Story: Wastewater Treatment and Source Reduction at L. Farber Co., Inc."** OTA Case Study.

2. **"'Immortal' Etchants,"** 1 p., OTA Technology Report.

Sebastian R. Sperber. Available for $47.50 from:

INFORM
381 Park Avenue SW
New York, NY 10016

20. Profit From Pollution Prevention: A Guide to Industrial Waste Reduction and Recycling, 234 pp., by Monica E. Campbell and William M. Glenn of the Pollution Probe Foundation. Available from:

Pollution Probe Foundation
as Madison Avenue
Toronto, Ontario
Canada M5R 2S1

21. **"Environmentally Safe Recovery of Silver from Photo Waste Material,"** 10 pp., by Benn Hermansson, American Fotokemi, Inc., from Massachusetts Hazardous Waste Reduction Conference Proceedings, 1984.

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Addendum